DOCUMENT RESUME

ED 069 897 VT 017 654

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TITLE	A Model of Individualized Instruction for the Clinical Laboratory Occupations. The UCLA Allied Health Professions Project.
INSTITUTION	California Univ., Los Angeles. Div. of Vocational Education.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C. Bureau of Research.
PUB DATE	Feb 72
NOTE	71p.
AVAILABLE FROM	University of California, Allied Health Professions Project, 1003 Wilshire Blvd., Santa Monica, California 90401 ($2.00)
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	Career Ladders; *Curriculum Design; *Health Occupations Education; Individualized Instruction; *Instructional Materials; Laboratory Technology; *Medical Laboratory Assistants; Medical Technologists; *Occupational Mobility; Paramedical Occupations; Subprofessionals; Task Analysis; Task Performance; Teaching Guides; Technical Education
IDENTIFIERS	*UCLA Allied Health Professions Projects

ABSTRACT

Utilizing the results from a task analysis, a consultant group with expertise in medical technology formulated a curriculum outline listing different levels of laboratory tasks according to the knowledge and skills required to perform them. Designed to enhance career mobility, the stages of learning for the clinical laboratory curriculum consist of: (1) entry level general laboratory skills and knowledge, and (2) basic skills in the clinical laboratory sections. The curriculum is composed of many courses, and within each course, there may be several units consisting of one or more modules having close content similarity. The modules, which are basic, self-contained instructional segments, begin with directions for student use, along with performance objectives, vocabulary list, and general introduction. This is followed by a skill lesson, which includes a specific performance objective, materials and equipment required, and a step-by-step illustrated procedure. A performance checklist and, in some modules, enrichment activities and reading assignments, complete the module. A sample instructional package consisting of an instructor's guide and instructional module for the hematocrit is included in this report. (SB)

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THE UCLA ALLIED HEALTH PROFESSIONS PROJECT

A MODEL OF INDIVIDUALIZED INSTRUCTION

for the

CLINICAL LABORATORY OCCUPATIONS

VT017654

UNIVERSITY OF CALIFORNIA, LOS ANGELES
DIVISION OF VOCATIONAL EDUCATION
ALLIED HEALTH PROFESSIONS PROJECT

FEBRUARY 1972

Reprinted March 1972

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A MODEL OF INDIVIDUALIZED INSTRUCTION

for the

CLINICAL LABORATORY OCCUPATIONS

Howard Taub
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Research and Demonstration Grant 8-0627
U.S. Office of Education, Bureau of Research
Department of Health, Education, and Welfare

UNIVERSITY OF CALIFORNIA, LOS ANGELES
Division of Vocational Education
ALLIED HEALTH PROFESSIONS PROJECT

February 1972
Reprinted March 1972

This publication was prepared pursuant to Grant 8-0627, Office of Education, Bureau of Research, U. S. Department of Health, Education, and Welfare. Points of view or opinions were developed on the basis of research and suggestions from the National Technical Advisory Committee, and with the cooperation of distinguished educators and practitioners. They do not, therefore, necessarily represent official Office of Education position or policy.

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FOREWORD

The Division of Vocational Education, University of California, is an administrative unit of the University which is concerned with responsibilities for research, teacher education, and public service in the broad area of vocational and technical education. During 1968 the Division entered into an agreement with the U.S. Office of Education to prepare curricula and instructional materials for a variety of allied health occupations. For the most part, such materials are related to pre-service and in-service instruction for programs ranging from on-the-job training through the Associate degree level.

A National Advisory Committee, drawn from government, education, professional associations in the health care field, and the lay public, provides guidance and help to the over-all activities of the Allied Health Professions Project. The following individuals and institutions participate in the activities of this nationwide interdisciplinary body:

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In addition, each of the specialized programs has the benefit of consultation with a National Technical Advisory Committee of practitioners, users of the services, educators, spokesmen for the national associations concerned, and physicians.

The Clinical Laboratory Occupations comprise one of the areas in which substantial progress has been made in the development of pre-service and in-service instructional materials. For this reason, curriculum materials designed for the training of laboratory workers has been selected to serve as an examplar of the developmental processes involved.

Melvin L. Barlow, Director
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I. BACKGROUND INFORMATION

Introduction

The Allied Health Professions Project (AHPP), a national curriculum research and development program funded by the U. S. Office of Education, initiated operations on a four-year grant in August of 1968 under the aegis of UCLA's Division of Vocational Education. Curricula and instructional materials of a unique and innovative nature for use in training a variety of allied health personnel are currently being developed by AHPP. These materials are being created specifically for the allied health functions that can appropriately be taught in pre-service and in-service educational programs.

The basic methodology of AHPP may be summarized as follows: After extensive field and library research, the findings were passed on to the occupational National Technical Advisory Committee to form a task list including all identifiable tasks and functions for each occupation. Data about each of the tasks in the list were obtained from a national survey. These data were analyzed and published in a Task Analysis report.* Using the results of this report, a consultant group with expertise in medical technology formulated a curriculum outline listing different levels of laboratory tasks according to the knowledge and skills required to perform them. All of the consultants were medical technologists of California registery, and most held MT(ASCP) certification. They had varied backgrounds--Joan Stock was an educational coordinator; Susanne Lange a chief technologist; Leila Walker a researcher and supervisor in microbiology and serology; Henry Raach an expert on automated technique; Gloriann Raach a counselor and manager in a clinical laboratory placement service; and Joan Tooley a clinical laboratory owner.

A. Establishing Curricular Levels

For the Clinical Laboratory curriculum, the stages of learning are labeled as follows:

Stage I - entry-level general laboratory skills and knowledge

Stage II - basic skills in the clinical laboratory sections

The learner begins at Stage I and progresses through Stage II. In other words, each stage builds on the knowledge and skills learned in the previous stage. (See Stage I and Stage II, Clinical Laboratory Occupations Content Outline, Appendix A.)

The continuing career sequence concept may be envisioned in the following broad interpretation for future development:

Stage III - comparable to present Paccalaureate degree in medical technology

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*The survey report was published by the UCLA Allied Health Professions Project in August 1971, as "Howard Taub et al., A Study of the Clinical Laboratory Occupations." The summarizing sections of this report appears in the Appendix.

Stage IV - comparable to a Master's degree

Stage V - comparable to a Ph.D.

The purpose of sequencing instructional materials into curriculum stages and introducing them to the student early in his health career is to provide the individual who successfully completes Stage I with a marketable skill, e.g., work as a laboratory assistant. This level of skill would also serve as a basis for future career mobility if the desire or need occurs.

Another advantage of this curricular approach is that the student will be performing laboratory tasks and learning laboratory skills at the very beginning, e.g., freshman year, of his formal education. A course in Microbiology, for example, would be more meaningful to the perspective medical technologist if he was required to inoculate media and isolate microorganisms from clinical specimens. It is hoped that as a spin-off of the establishment of content levels, greater motivation will be generated to continue upward in the career sequence.

The curriculum is established as an open-entry/open-exit plan, permitting optimal use of faculty, educational materials, and instructional clinic settings.

B. Organizing the Course Content in Each Stage

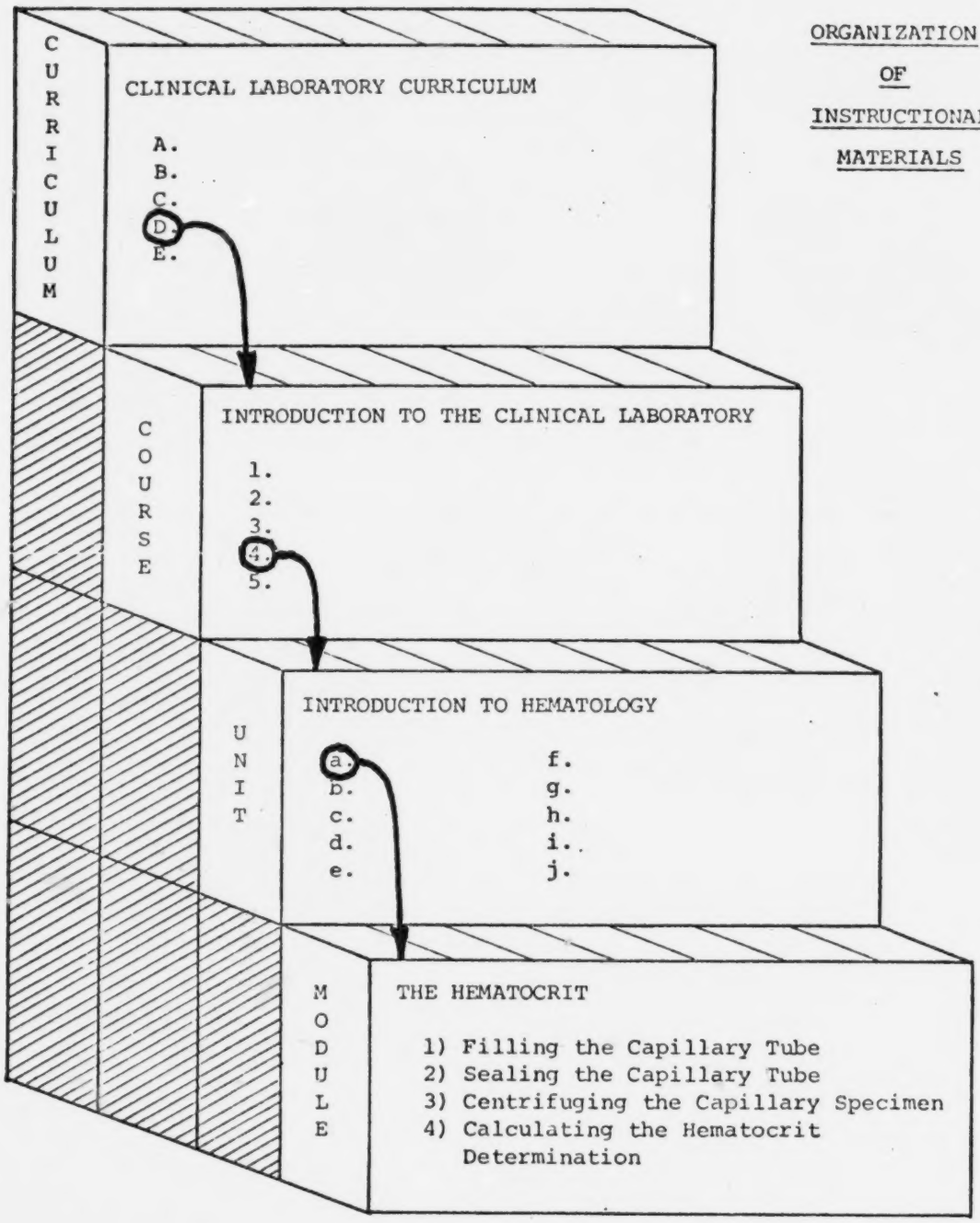
The diagram on the following page shows AHPP's organization of instructional materials for the clinical laboratory. The top of this chart represents the entire clinical laboratory curriculum, which is composed of many courses, such as Fundamental Skills in the Clinical Laboratory and Introduction to the Clinical Laboratory Sections.

The next step down shows the courses. Within the course of Introduction to the Clinical Laboratory, there may be many units of instruction, such as introductions to the laboratory sections of Clinical Chemistry, Urinalysis, Microbiology, Hematology, etc. A unit of instruction is composed of one or more modules which have close content similarity. The unit, "Introduction to Hematology" (third step in sketch), is made up of 10 modules, such as The Hematocrit, Hemoglobin, etc. A module is defined as a basic, self-contained instructional segment. The Hematocrit is shown on the fourth step in the sketch.

Each module begins with directions to the students for its use, along with performance objectives, vocabulary list, and a general introduction or general comments about the content. This is followed by a skill lesson which includes a specific performance objective, materials and equipment required, and a step-by-step illustrated procedure. A performance checklist, and in some modules, enrichment activities and reading assignments for review, complete the module.

Since all important concepts related to each particular skill are included in the module, the need is virtually eliminated for a lecture preceding the laboratory or clinic period. The student spends most of the period working and learning independently, and the instructor is free to provide direct individual instruction. The performance checks insure that each student has mastered all the necessary skills before moving on to more complex procedures.

CLINICAL LABORATORY OCCUPATIONS



ORGANIZATION OF INSTRUCTIONAL MATERIALS

Component modules may be used in several settings: in-service programs, adult education programs, trade schools, Associate degree programs, and programs leading to medical technology licensure. Because these modules may be used in various settings, it is believed that they will help achieve standardization of practice at a level of excellence. The specific sequencing of content will remain the responsibility of the individual instructors.

In preparing the instructional modules, an effort has been made to be innovative while providing a sound educational basis for the program. AHPP has endeavored to simplify (but not to water down) content in the following manner by:

1. Designating the skill (activity or task) to be learned

2. Subdividing the practical content with related theory which will clarify the major steps, e.g., factors which make or break the successful attainment of the skill: safety precautions; points for making the step easier to do (special timing, special handling or positioning, special sequence of action); related biological concepts or principles of microbiology, where applicable; communication and human relations skills needed for successful completion of the activity; pertinent ethical or legal concepts

3. Planning the learning sequence

   a. Demonstration or film introducing the unit

   b. Study of the Instructional Unit, followed by written review questions (no grade)

   c. Practice in learning lab, taking performance test (pass/unsatisfactory)

   d. Supervised clinical practice with periodic evaluation checks

II. INSTRUCTIONAL PACKAGE

The following instructional package consists of:

An Instructor's Guide for Using the Module

An Evaluation Guide for Determining the Effectiveness of the Module

An Instructor's Guide for Using The Hematocrit Module

An Instructional Module: The Hematocrit

A. Instructor's Guide for Using the Module

If you have never used the modular approach to learning, you are in for some new experiences, both positive and negative. The following conclusions are the result of the use of this method in a clinical setting:

Positive Aspects

1. More individualized instruction time available to students. The instructor gets to know the student better; a chance for better rapport is present.

2. More rapid assimilation of the materials with higher performance abilities.

3. High motivation demonstrated by both the students and the faculty as evidenced by the increased performance capabilities of the students.

4. Approval of this innovative approach to teaching by the instructors. The new method proved most stimulating to the teachers who had formerly used traditional methods.

Negative Aspects

1. Initial frustration was experienced by the instructors who felt that the students could not learn without receiving "pearls of wisdom" from them in a formal lecture setting.

2. Embarrassment at being unable to answer students' questions which are asked with increased frequency when instruction becomes personalized on a one-to-one, teacher-student basis.

3. Difficulty experienced during the early weeks in coping with the new system and handling the logistics of working with students who were at varying stages in the curriculum.

General Suggestions for Using the Modular Approach

1. It is extremely important that you DO NOT LECTURE ON MATERIAL COVERED IN THE MODULES. Read the module thoroughly in advance, and then lecture, if you must, only on specific information which was not covered in the text. Do not subject the student to unnecessary repetition. Clinically oriented tasks are most effectively taught by "doing" and the student will absorb more information if he is expected to perform the task immediately.

2. NO READING ASSIGNMENTS on MATERIAL COVERED IN THE MODULES should be given until <u>after</u> the student has completed the module. Reading assignments should be given as enrichment. After performing the procedures and handling the instruments, the student should be interested and motivated to read more on the subject.

3. Review the module carefully for content.

4. Assemble required supplies, equipment and aids; arrange for adequate laboratory or clinic space before class time.

5. Introduce the module by giving its title. Distribute copies of the module and tell the students to read "Directions to the Student" and "Performance Objectives." Answer any questions that the students ask.

6. Give small group demonstrations of the skills to be learned.

7. As the students begin performing the step-by-step skills exercises, circulate among them to answer questions and provide assistance and clarification of the procedure. This experience is most valuable both to the student and to you; you will be doing a great deal of individual counseling at this time, and may find this to be unusually demanding because the students may be asking you many questions.

8. After performing the exercises, the student may be given the Review Questions, Page 13. He can correct them by using the answers provided on Page 14. Since you will not be grading the Review Questions, remind the students that they may be held responsible for all material covered in the modules on course examinations. Perhaps this will insure that the students will carefully read and answer all of these questions.

9. When the student is ready, he should ask you for a <u>performance check</u>. If you are occupied with another student, he may begin reading the next Skills Lesson or start on an enrichment activity until you are able to check him. Make sure that he has filled out all necessary information on the Performance Checklist (see Hematocrit module, Page 37). If this is the student's first performance test, give him a copy of "General Instructions to Students Taking Performance Tests," Appendix B, Page 58.

10. The directions for administration of each performance test should be followed as closely as possible so that a standard set of conditions is maintained for all occasions on which a test is given. The directions are designed to make the test conditions similar to those that the student will encounter on the job. Most of the tests, therefore, are arranged so as to require the student to make the appropriate preparations for performance (which may include locating and assembling the correct equipment) and to complete the necessary follow-up activities after performance of the basic task (see Discussion Section, Page 9).

B. Evaluation Guide

The purpose of the evaluation is:

1. To provide a primary assessment of the effectiveness of instructional units in the Clinical Laboratory Curriculum.

2. To determine if this instructional module provides sufficient learning experiences (quantitatively and qualitatively) to enable the students to attain the performance objectives.

3. To develop student profile data which will describe the essential prerequisites, abilities, and attitudes which are necessary to permit successful completion of the program. This will fill the possible need to develop additional learning experiences for those students who are having difficulties but otherwise seem to meet the required criteria.

4. To establish the economic feasibility of this instructional program.

Not all of the above can be accomplished after completing a single module in the curriculum; only No. 1, above, the primary assessment, and No. 2, the determination of whether the performance objectives have been accomplished, will be attempted for the module The Hematocrit.

Evaluation Method

1. Utilization of the Module's Performance Test to Determine the Student's Ability to Meet the Unit's Performance Objectives (see Page 18 for specific instructions)

   a. The Performance Test will be given in a standardized test situation apart from other students (see Hematocrit module, Page 35).

   b. The student performance is evaluated by means of a Performance Checklist that itemizes behavioral steps deemed necessary for successful attainment of the performance objectives (see Hematocrit module, Page 37).

   c. The student performer is rated by the instructor on a pass or unsatisfactory basis.

d. The initial performance evaluation will be in the learning laboratory. Succeeding performance evaluations will be made in the clinical setting.

e. Time-lapse performance evaluations will be made at intervals to determine if and when unsatisfactory performance levels occur.

2. Collection of Feedback Information

a. Student Evaluation (Appendix C, Page 59).

b. Instructor Evaluation (Appendix D, Page 60).

3. Development of Statistical Information to Describe the Essential Characteristics Which Could be Expected to Lead to Successful Completion of the Program

a. Student demographic information to include education, socio-economic, work experience, manual dexterity, and other basic indices (see Student Background Data Form, Appendix E, Page 62).

b. Individual learning time and performance.

C. Instructor's Guide for Using The Hematocrit Module

In this Instructor's Guide the following items are discussed:

Target Group: The student population for whom the module is intended.

Materials and Equipment: Lists all the necessary apparatus and materials needed to complete the module.

General and Specific Performance Objectives: States in behavioral terms exactly what the student should know or be able to do at the completion of the module.

Discussion Section: Gives suggestions about how to use the modules most effectively.

Review Questions: Short answer, self-grading questions. The Review Questions are not designed as test items. It is suggested that the students correct their own papers using the Answer Keys provided.

Evaluation Section: Describes the use of the Performance Test, Student and Instructor Evaluation Forms, and the collection of student demographic information.

Target Group: Stage II Student, Clinical Laboratory Occupations

Materials and Equipment:

1. Whole blood sample (with anticoagulant)
2. Capillary tubes (blue tip)
3. Sealing clay
4. Tissue or gauze (2 by 2 inches)
5. Microhematocrit centrifuge
6. Metric ruler
*7. Wintrobe tube
*8. Centrifuge
*9. Pasteur pipet
*10. Capillary tubes (red tip)
*11. Bunsen burner
*12. Microhematocrit tube reader
*13. Microhematocrit tube reader card

General Performance Objective:

Given a blood sample, capillary tube, sealing clay, microhematocrit centrifuge, and a small metric ruler, perform a microhematocrit test within 10 minutes to a ± 2% accuracy.

Specific Performance Objectives:

1. From an assortment of tubes, select those which can be used for the macromethod and micromethod determination of the hematocrit.

2. Read the hematocrit of a sample of blood, using three capillary tubes, with a maximum difference of ± 2% between the highest and lowest value.

3. Recite from memory the formula for calculating the microhematocrit.

4. Orally give the normal range of values for the hematocrit for the adult male and adult female. Also, describe briefly the variation of a normal hematocrit value according to the age of the patient.

5. Given any word on the vocabulary list, provide a precise one-sentence definition.

Discussion Section:

1. Read the entire module, noting any content such as descriptions or procedures that are different from those in your laboratory.

2. Before class time, assemble all the required materials and equipment listed above; arrange for adequate laboratory space.

3. Tell the students that they are going to learn how to perform the Hematocrit Determination, a common Hematology procedure.

---

*Enrichment only.

4. Distribute copies of the module to the students and ask them to read the first two sections of the Introduction, "Directions to the Student" and "General and Specific Performance Objectives." Answer any questions that the students ask.

5. Explain any changes in the module's content that you wish to be made. The students should write these changes in the module.

6. Demonstrate the entire microhematocrit procedure at a slow pace. The students should follow <u>each</u> step while referring to their module, Pages 20 through 32. Answer any questions or repeat any steps at the student's request.

7. Give each student a tube of non-clotted blood, two blue tip capillary tubes, sealing clay, tissue or gauze, and a metric ruler.

8. Tell the students to re-read the module, beginning on Page 19 and then to practice each step of the procedure, Pages 20 through 32.

9. Inform them that you will be available to answer questions and provide assistance and clarification of the procedure.

10. As the students begin performing the step-by-step exercises, circulate among them. They may at first be reluctant to ask questions (in a conventional class only the "dummies" ask questions); however, encourage them to do so.

11. When a student feels that he (she) is ready to be tested on the procedure, you will be asked to initial the Instructor's Check in the Performance Test, Page 35 in the module (blue sheet). Remind students that they must be able to do all five parts <u>without</u> the use of notes.

    If this is the student's first Performance Test, give him a copy of "General Instructions to Students Taking Performance Tests," Appendix B, Page 58.

    If another student is also ready to do the Performance Test, pass out a copy of the review questions (and answers) or have him begin one of the enrichment activities (see module [yellow], Pages 39 through 52).

12. After the student fills out all necessary information on the Performance Checklist (pink) in the module, he will tear it out and hand it to you.

13. The checklist items have been arranged in the order in which observations of the activities probably would be made. Some items, however, will depend more on observation of the entire procedure than on observation at any one specific point.

    The observer should indicate his rating of the student's performance on each item by checking one of the four columns.

    COLUMN 1 Yes: the student correctly performed as required by the item.

COLUMN 2 No: the student did not perform correctly, or failed to perform when he should have done so.

COLUMN 3 Not Applicable: the activity was not performed because it was not appropriate in the circumstances.

COLUMN 4 Not Observed: the observer was unable to observe the student's performance, or he was unable to judge whether or not the student's performance was correct.

The last item on the checklist requests the observer's judgment of the student's overall performance of the procedure as a whole. Since each checklist item, when applicable, is necessary to complete the activity, a 100 percent satisfactory performance is recommended as the criterion for passing. The definitions of the categories are:

a) Pass: The student has been properly trained so that he knows what to do and how to do it, and with further practice he should have no difficulty in attaining the required level of proficiency.

b) Unsatisfactory: The student's overall performance is clearly deficient, and indicates that his understanding has not been adequate.

Space has been provided for the performance check time (total time for student to complete the performance checklist) and for comments if the observer wishes to qualify any of his ratings. If the observer judges that there was an error or a deficiency in some aspect of the student's performance that is not covered in the checklist, he should indicate in this space what it was.

The student should be allowed to continue through the test without guidance or correction from the observer. However, if the student is unable to continue, or if the observer considers that his performance might cause harm to the patient, the test may be stopped and the student given an overall rating of "unsatisfactory." The student will then return to the skill lab for further practice, or may be counseled and asked to withdraw from the program because of consistently unsatisfactory performance.

14. If at the completion of the checklist the performance is unsatisfactory, record this decision in the blank titled "Trial No. 1" and suggest that the student review the lesson. Answer questions and provide individual instruction as required. When the student is ready, he must request a second performance check: this should be recorded in "Trial No. 2." If the student requires more than two checks, indicate the total number of checks and explain the situation in the space for comments. Such a situation would also probably call for an Instructional Material Deficiency Report Form.

If the performance is satisfactory, sign the sheet, record the performance check time, make comments if necessary, and tear the page out. Collect the Checklists and file them in the Individual Student File Folders.

15. Instead of beginning the next module immediately, the student may be offered one of several options:

    a. Assist slower students in the laboratory. (Make this a positive experience and not a penalty for finishing the module early.)

    b. Pursue some of the enrichment assignments in the laboratory or library, such as reading laboratory journals.

    c. Observe technologists working on patients, if schedule permits.

    d. Other constructive activities.

16. Give the student a "Student Module Evaluation Form" and tell him to fill it out as completely as possible. Make it clear that his opinions are important and necessary to improve the instructional materials.

Review Questions: (Fill in the blanks.)

1. The test which reports the percentage of red cells in a sample of whole blood is known as the_____.
2. The average hematocrit value of the adult male is _____vol. %.
3. The_____comprise the largest layer on a centrifuged blood sample.
4. After centrifugation, a layer composed of white cells and platelets is formed right above the red cell layer. The layer is known as a_____ layer.
5. The_____tube is used for the determination of the macrohematocrit.
6. The method of choice for sealing capillary tubes is to use_____.
7. Capillary tubes are avilable with red or blue tips. The red tip capillary tube contains_____. It is used on blood that has been obtained from a_____. If a blue tip capillary tube was used, the blood sample collected above would_____.
8. List three of the four chief components of whole blood:

   _____ _____

   _____
9. Another name given the hematocrit is the_____ _____volume.
10. Define hemolysis: _____

    _____.
11. Define oxalated blood: _____

    _____.
12. Define capillary attraction: _____

    _____.

Answers to Review Questions:

1. Hematocrit
2. 47 vol. %
3. red blood cells (RBC or erythrocytes)
4. buffy
5. Wintrobe
6. clay
7. heparin; finger puncture (ear, capillary); clot
8. red blood cells; white blood cells; plasma; platelets
9. packed cells
10. hemoloysis: the destruction of red blood cells.
11. oxalated blood: a blood sample that contains oxalate.
12. capillary attraction: the force that makes a liquid fill a capillary tube without the necessity of using gravity.

Evaluation Section:

1. Performance Test - Unlike a written paper and pencil test, which measures a student's knowledge of a skill, the performance test determines if the actual skill can be performed satisfactorily. A student may be able to describe exactly the entire step-by-step procedure and therefore score 100% on a written test. However, he may be unable to obtain an accurate Hematocrit determination upon completing the three-part procedure. From a practical and sound medical point of view, the latter (performance of the skill) is the desired objective in a training program, if both cannot be achieved.

2. Student Module Evaluation Form (Appendix C) - The information on this form provides the instructor with valuable information from the student's point of view for improving the module. This form is filled out after the student completes the module and is then given to the instructor before he is allowed to begin work on the next module.

3. Instructor Module Evaluation Form and Instructional Deficiency Report Form - When the last student in the class has completed the module, fill out the Instructor Module Evaluation Form (Appendix D) and the Instructional Material Deficiency Report Form (Appendix H). It is best to do this immediately after finishing the module; otherwise, problems, resolutions, and ideas quickly fade from mind as you progress through the successive modules.

4. Instructor Background Data Form (Appendix G) - The purpose of this form is to determine if the instructor's educational background or experience is a factor in the student's performance on the instructional material. All information is confidential.

5. The Allied Health Professions Project would like your comments on the modular approach and on this module. If you have used the module, we would appreciate receiving copies of the Evaluation Forms and the Performance Checklist. If you would like your laboratory facility to become a test site for our entire curriculum when it is completed (in which case you will be given all the instructional modules free), or if you would like more information, please write or call:

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THE HEMATOCRIT PROCEDURE

PART I: INTRODUCTION

A. DIRECTIONS TO THE STUDENT

You are to proceed through the lesson using this workbook as your guide. You will need to practice the tasks, using the materials and equipment listed. The instructor is available to assist you whenever you have a problem. After you have completed the lesson and practiced the tasks, arrange with your instructor to take the Post Test and Performance Test.

To complete this lesson you will, of course, need this workbook and a pen or pencil. In addition, you will need the following items of materials and equipment:

1. Whole blood sample (with anticoagulant).
2. Capillary tubes (blue tip).
3. Sealing clay.
4. Tissue or gauze (2 by 2 inches)
5. Microhematocrit centrifuge.
6. Metric ruler.

Please read the following paragraphs carefully. They will tell you what you will be expected to know and do when you have completed these lessons. When you feel that you have sufficient knowledge and skills to achieve the performance objectives without further study of the lessons, please discuss this with your instructor. All students are expected to perform accurately the skills required in the performance tests without the use of reference materials.

B. GENERAL PERFORMANCE OBJECTIVE

Given a blood sample, capillary tube, sealing clay, microhematocrit centrifuge, and a small metric ruler, perform a microhematocrit test within 10 minutes to a ± 2% accuracy.

C. SPECIFIC PERFORMANCE OBJECTIVES

1. From an assortment of tubes, select those which can be used for the macromethod and micromethod determination of the hematocrit.

2. Read the hematocrit of a sample of blood, using three capillary tubes, with a maximum difference of ± 2% between the highest and lowest value.

3. Recite from memory the formula for calculating the microhematocrit.

4. Orally give the normal range of values for the hematocrit for the adult male and adult female. Also, describe briefly the variation of a normal hematocrit value according to the age of the patient.

5. Given any word on the vocabulary list, provide a precise one-sentence definition.

D. VOCABULARY

anticoagulant------a chemical that prevents blood from clotting.

buffy layer (buffy coat)------the layer formed by the white cells and platelets when a sample of whole blood is centrifuged.

capillary attraction (capillary action)------the forces that make a liquid fill a capillary tube without the necessity of using gravity.

coagulation------a term meaning clotting.

"crit"------an informal abbreviation for the hematocrit.

heparin------one of the more common chemicals used as an anticoagulant to prevent blood from clotting.

hematocrit------the percentage of red cells in a given sample of blood.

hemolysis (hemolyzed)------the destruction of red cells, indicated by a pink to red tinge imparted to the plasma.

macroprocedure------a determination or test that uses a generous amount of specimen.

MCHC (mean corpuscular hemoglobin concentration)------a measure of the relationship between hemoglobin and hematocrit.

microprocedure------a determination or test that uses a small amount of specimen (usually a drop or less).

microhematocrit------a microprocedure used to determine the hematocrit.

microhematocrit centrifuge------a centrifuge especially designed for the spinning down of the microhematocrit.

oxalate------a commonly used anticoagulant.

oxalated blood------a blood sample that contains oxalate.

packed-cell volume (P.C.V)------a term synonymous with the word "hematocrit."

plasma------the liquid portion of unclotted blood.

platelet (thrombocyte)------a very small blood cell that is involved in the formation of blood clots.

red blood cell (RBC)------a small blood cell which contains hemoglobin (the red coloring matter) and carries oxygen to the body tissues.

volume percent (abbreviated vol. % or %)------the unit of measure in which the hematocrit is reported.

white blood cell (WBC) (leukocyte)------a cell, slightly larger than a red cell, that primarily protects the body from infection or disease.

Wintrobe tube------graduated test tube designated for the macroprocedure method of performing the hematocrit.

PART II: THE HEMATOCRIT

1. GENERAL CONCEPTS ON THE HEMATOCRIT PROCEDURE

In the introduction to the complete blood count, a brief review was given on the basic components in blood (red blood cells [RBC], white blood cells [WBC], and platelets). It was also emphasized that the red cell count is time-consuming to perform manually and highly inaccurate. The HEMATOCRIT is now used by most laboratories in place of the red cell count. It is simple to perform and very accurate.

The average adult male has approximately 5 million red cells in every cubic millimeter of whole blood. Looking at this another way, about 47 percent of his blood is composed of red cells. This is the basis of the hematocrit. The results of this test indicate what percent of the patient's blood is composed of red cells. This determination is made by placing a well-mixed specimen of non-clotted (e.g., oxalated) blood into a tube that has a uniform bore. After one end is sealed, the tube is centrifuged at high speed for a period of time necessary to force all the red cells down to the bottom of the tube. The depth of the red cells in the total fluid (cells and plasma) is measured. The hematocrit report is the percentage of red blood cells (RBC's) in the whole blood. Because the red cells are packed at the bottom of the tube, the hematocrit is often referred to as the packed-cell volume (PCV). When discussing this test, the abbreviation "crit" is sometimes used.

Normal hematocrit values vary with age and sex, as shown on the table below.

NORMAL HEMATOCRIT VALUES

Age	Range (%)	Average (%)
Newborn	44-64	54
1 year	30-40	35
10 years	32-42	37
Adult men	40-54	47 (after 50 yr. = 40)
Adult women	37-47	42 (after 50 yr. = 37)

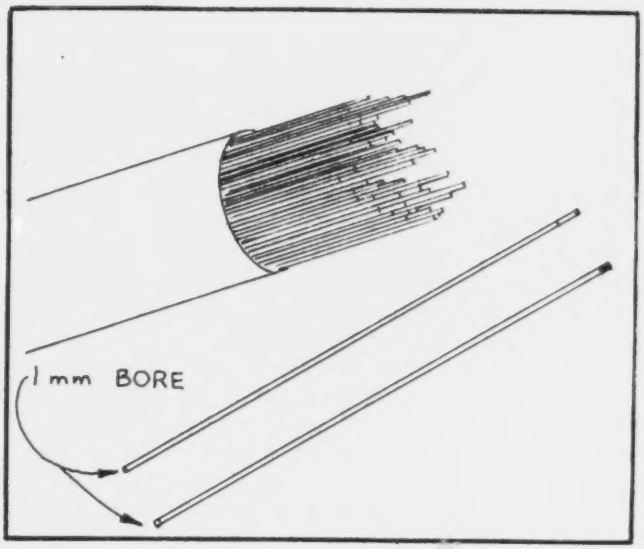
The two methods used in the determination of the hematocrit are the micromethod and the macromethod. The micromethod will be described in detail here; the macromethod will be briefly outlined in the Enrichment Section.

2. Procedure: The Microhematocrit

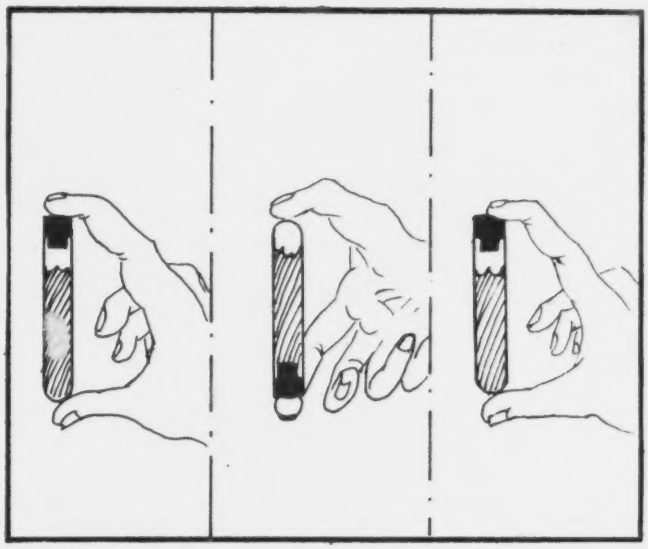
A. Filling and Sealing the Capillary Tube

Introduction

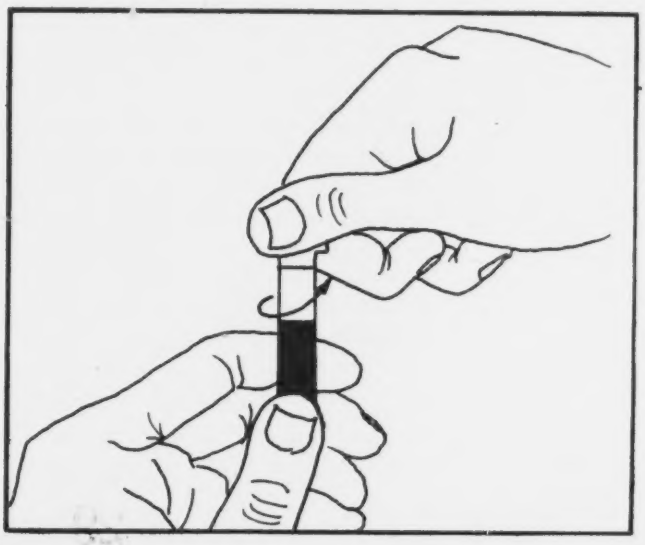
The capillary tube that is used in the determination of the hematocrit or packed cell volume is manufactured expressly for this test. The bore of this tube is uniform throughout. One tip has a colored band, either red or blue. The red band indicates that the tube contains heparin; the blue band indicates it is "plain," containing nothing. The blue tip capillary tube is used with an oxalated blood sample; the red tip is used when blood is collected directly from a finger puncture. Instructions for use of the red tip capillary tube will be discussed in the Enrichment Section of this lesson.



(1) Mix the sample of blood thoroughly but gently. Invert back and forth 10 to 15 times; do not shake it. If the specimen has been sitting for an hour or longer, then additional mixing is required. A mechanical rotator can also be used.

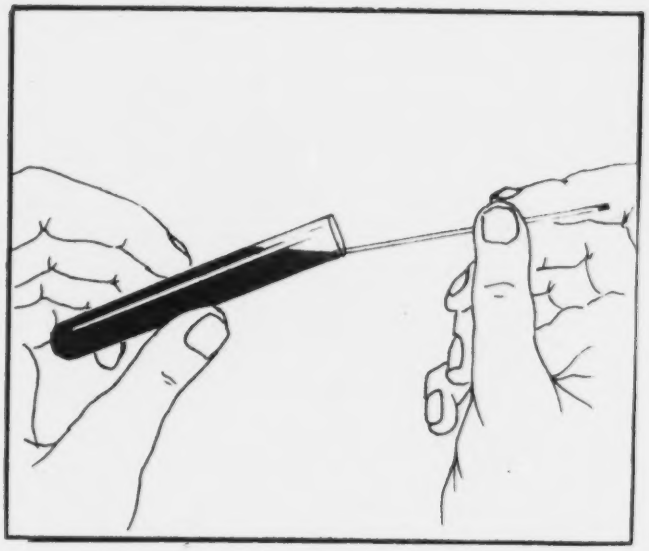


(2) Remove the cap or stopper from the tube. Twist the stopper out, rather than pulling it. Otherwise, blood might splatter over you and your work area. Covering the stopper with gauze before removing will prevent blood from getting on the fingers. This is a safety precaution since some diseases are spread by the blood of sick patients.



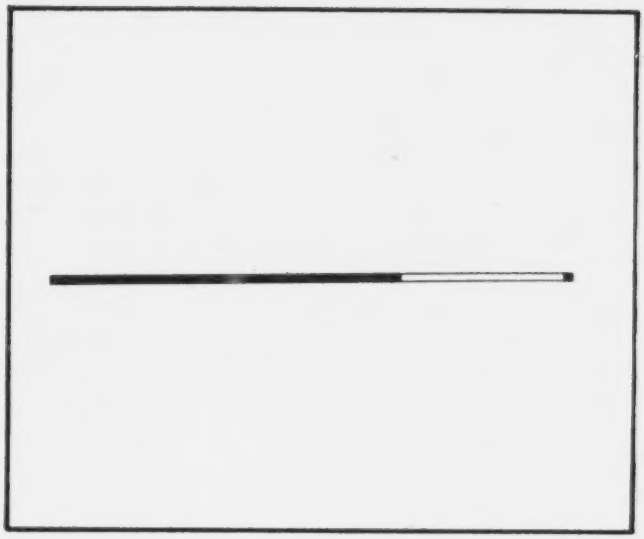
(3) Tilt the tube of blood so that the blood approaches the lip of the tube. Do this slowly because blood at first does not flow freely, but then moves rapidly.

Insert the plain end of the capillary tube into the blood and hold it at an angle, so the blood flows into it. Filling of blood in this manner is known as CAPILLARY ATTRACTION.

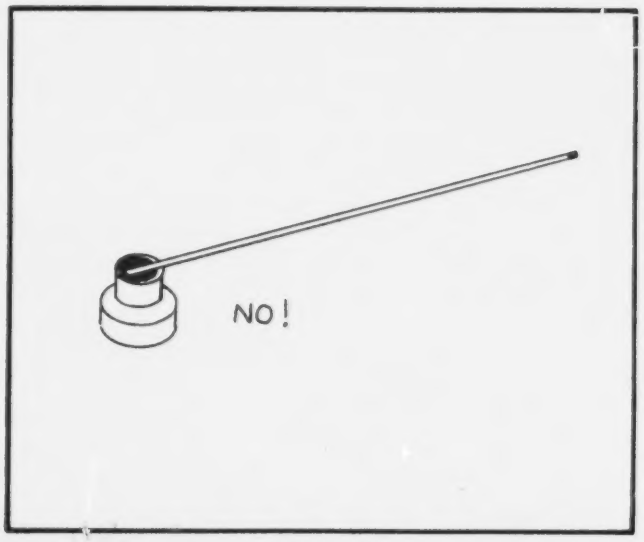


(4) Fill the capillary tube about two-thirds full and then remove. Hold it on a horizontal plane so that the blood does not move inside the capillary tube. Do not let the blood move to the colored tip as it will later interfere with an effective seal.

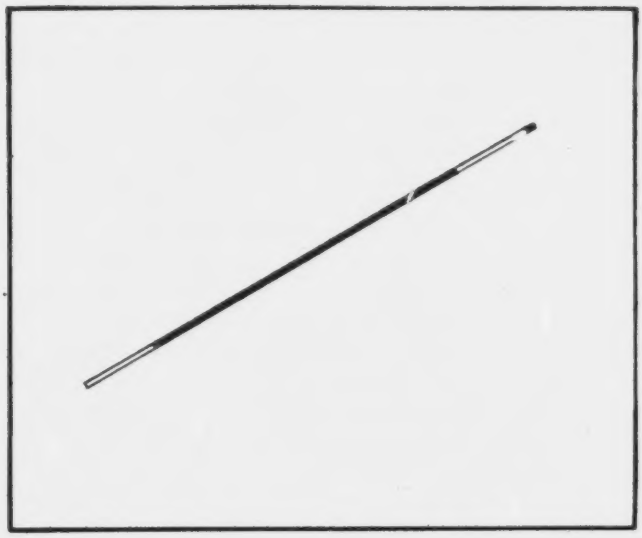
Air spaces in the blood will not affect the performance of the hematocrit unless there is too much air to permit a sufficient quantity of blood to at least half fill the capillary tube.



Some persons prefer to fill the capillary tube from blood that has collected in the stopper. This is definitely NOT recommended. Dried red cells or plasma in the stopper can contaminate the test and give erroneous results.

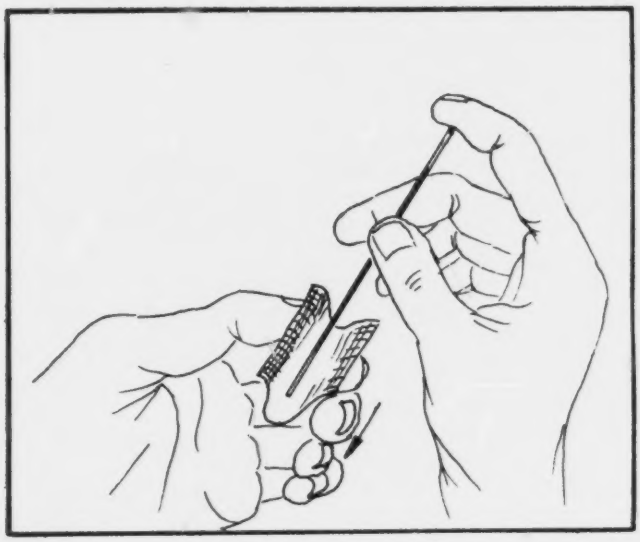


(5) Tilt the capillary tube back so that blood is in the middle of the tube with empty tubing of equal distance at both ends.



(6) Place your index finger on the end of the colored tip. This will keep the blood suspended in the same position no matter at what angle you hold the capillary tube.

Wipe the blood off the outside of the dirty tip with tissue or gauze. Use only a downward motion; do not rub up and down.

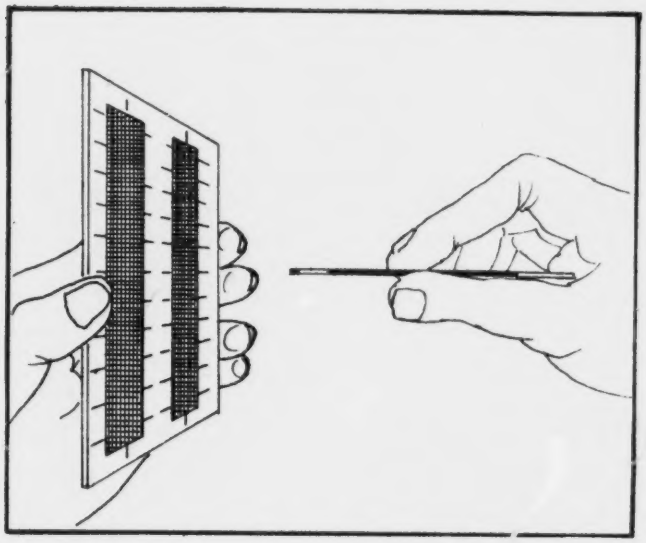


Wher wiping off the tip, it is important to keep your finger pressed on the other end so that the blood will not flow towards the end you are wiping. If the blood is in touch with the tissue or gauze, it will be attracted in unequal amounts. In other words, more plasma than red cells will escape and the blood remaining will NOT be representative of the patient's blood. Then, this specimen must be discarded and a new one prepared.

(7) Seal the colored tip with clay.

The use of clay is the method of choice. Two other methods of sealing the tip are with heat from a burner (see Enrichment Section C) or with a plastic cap.

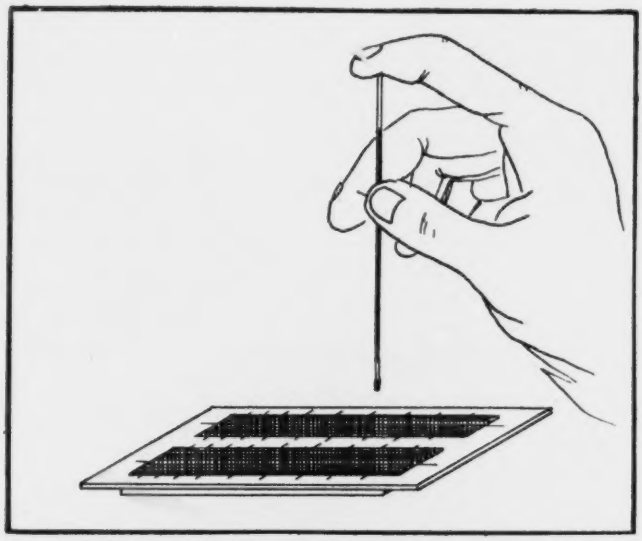
Hold the clay holder in a vertical (up and down) position in one hand. With the colored tip facing the clay, hold the capillary tube between thumb and index finger in a horizontal position about midway between both ends or closer to the colored tip. Be certain the blood is not near either end.



Blood that is too close to the plain end (i.e., the end nearest the palm of the hand) will escape when sealing the other end, thus making the procedure worthless.

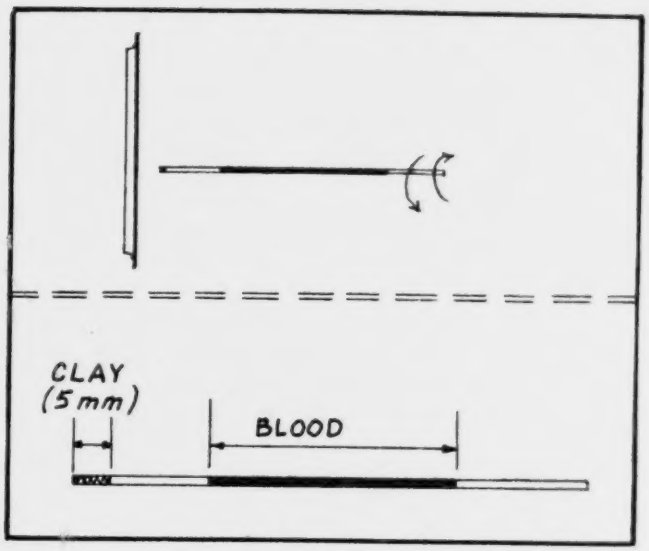
Holding the tube too near the plain tip will almost guarantee its breaking when Step h is performed.

An alternative method of holding the capillary tube is to place your index finger over the plain end. This will prevent the blood from moving around or leaking. The plain tip can be kept covered in this manner until the other end is placed in the clay. Once contact has been made with the clay, the index finger may be removed. For this method, the clay holder usually is placed on the bench top in a horizontal (flat) position.



(8) Push the tip into the clay while twisting the tube back and forth by rotating the thumb and index finger. DO NOT PRESS HARD. The clay should enter the tube to a distance of about 5 mm (see drawing). If not, repeat this step. Watch the other end of the capillary tube because, as the clay enters one end, the blood is forced up to the other end and could leak out.

If there has been blood present in the space now occupied by the clay, there is a chance that the seal will not be a good one.

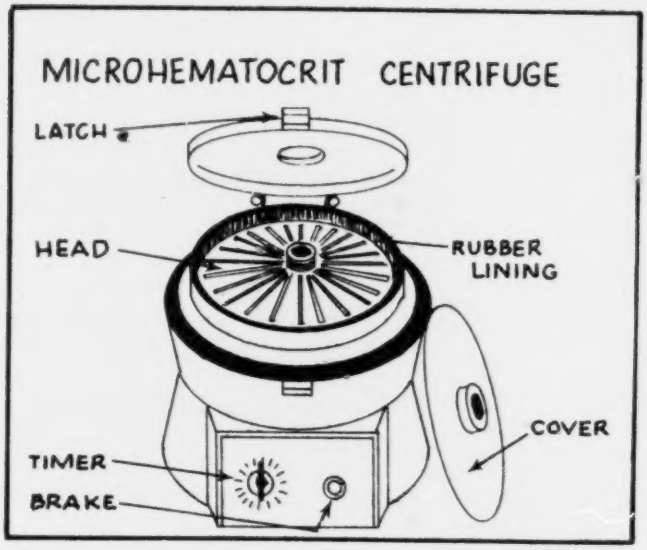


Even after sealing, the sample cannot be left unattended for too long a period of time. Some of the plasma will evaporate and this can raise the hematocrit reading considerably, resulting in an incorrect reading. If the sample is not processed further immediately, it is advisable to seal the tube by placing some clay in the open plain end. This will not affect the final reading.

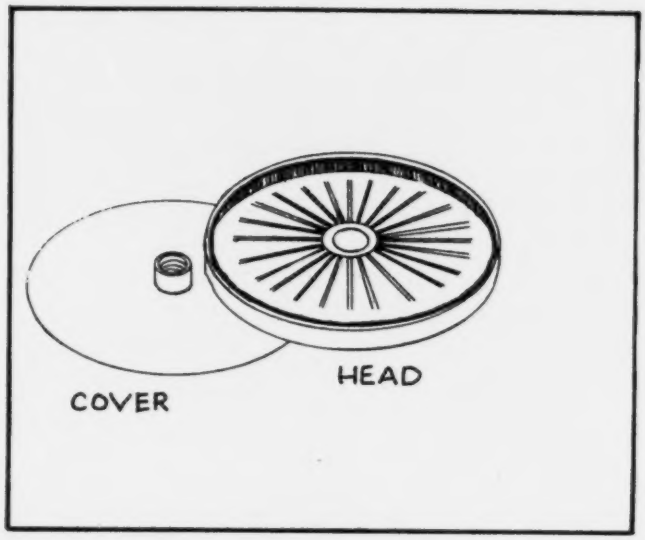
B. Centrifuging the Specimen

Introduction

The microhematocrit centrifuge is designed expressly for use in the microhematocrit determination. The head of this centrifuge holds up to 24 capillary tubes in small slots or grooves. The centrifuge spins or rotates at a very high speed so that the red cells are completely packed down within three minutes. As you will learn later, this is an advantage over the older macrohematocrit method.

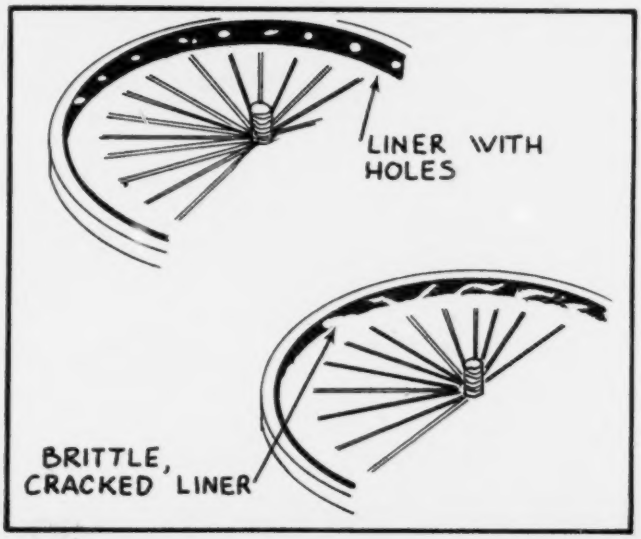


The head of the microhematocrit centrifuge has 24 slots or grooves, each for comfortably holding a capillary tube. Each groove is identified by a number. Make use of these numbers for identifying the specimen. For example, patient Jones is #1, patient Smith is #2, etc. Leaving an empty groove between patient samples, if this is practical, reduces the possibility of confusing specimens. Because capillary tubes are so light, it is not necessary to balance the centrifuge with tubes directly across from one another.

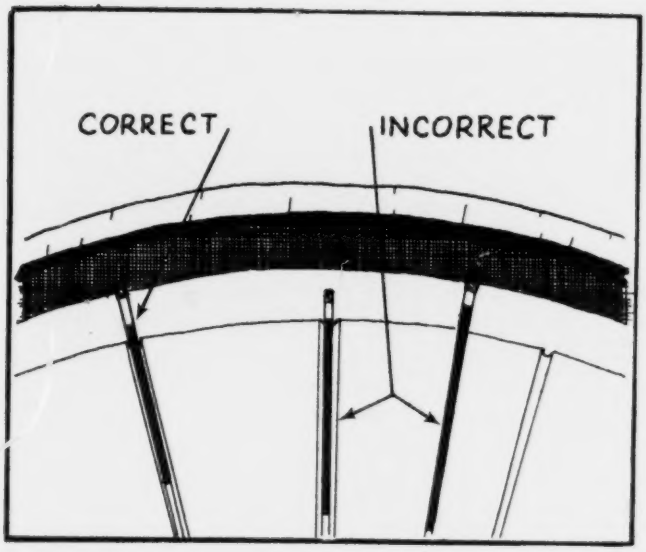


The inside rim of the head of the microhematocrit centrifuge has a rubber lining which should be replaced when worn out. The purpose of this liner is to act as a cushion between the sealed end of the capillary tube and the metal rim. It also prevents the clay from being forced out, which would result in a loss of the specimen.

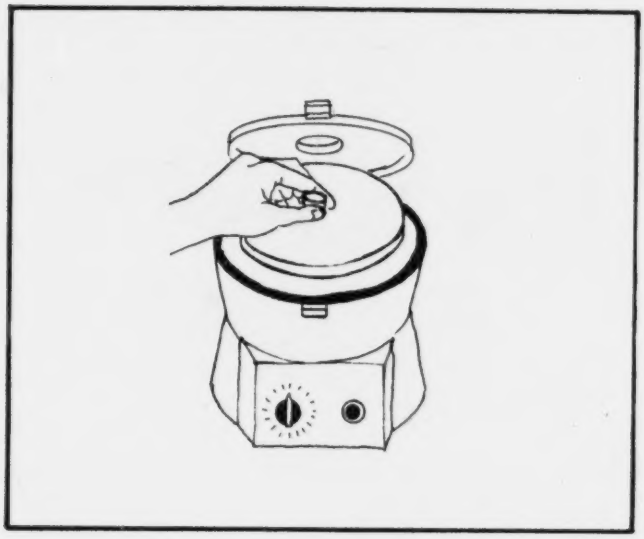
Always check this rubber liner before using the centrifuge. If there are any holes present, rotate it so the capillary tube rests against an unbroken surface. If the lining has become brittle, replace it.



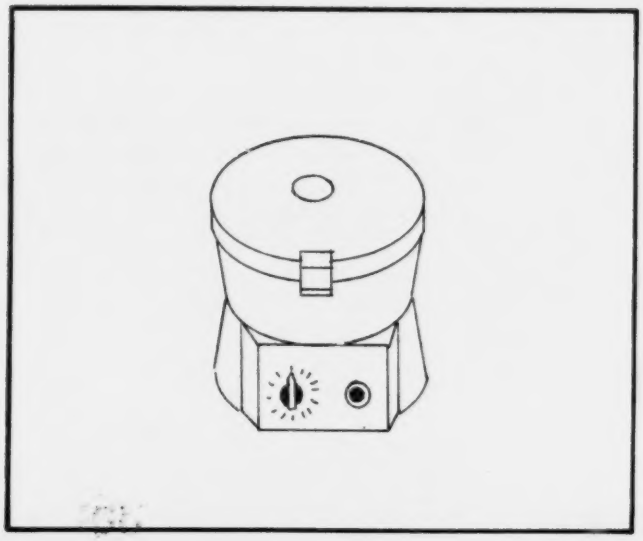
(1) Place the capillary tube in its assigned groove with the sealed end against the outside rubber liner. The groove number should correspond to the laboratory number on the label of the tube of blood. Be sure the end of the tube is actually against the outside rubber liner. This reduces the chance of breakage. Also, double check that the tube is seated properly in the groove and not partly protruding, especially at the ends.



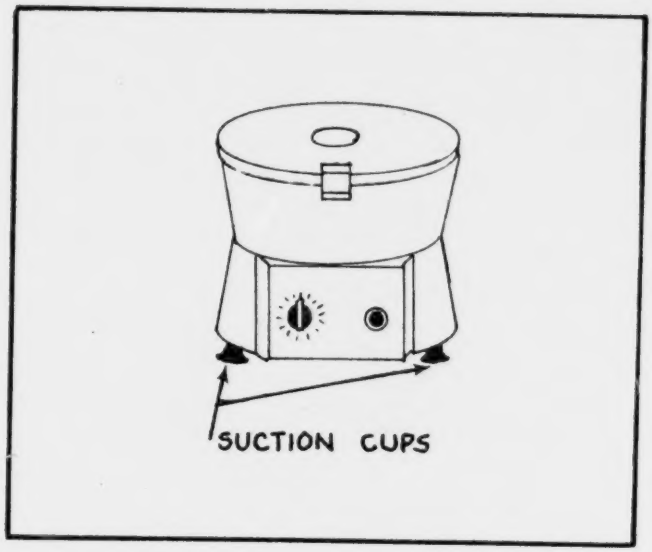
(2) Place cover on head and hand tighten (do not use a wrench) until there is no give. Do not over tighten.



(3) Close and lock the lid of the microhematocrit centrifuge.

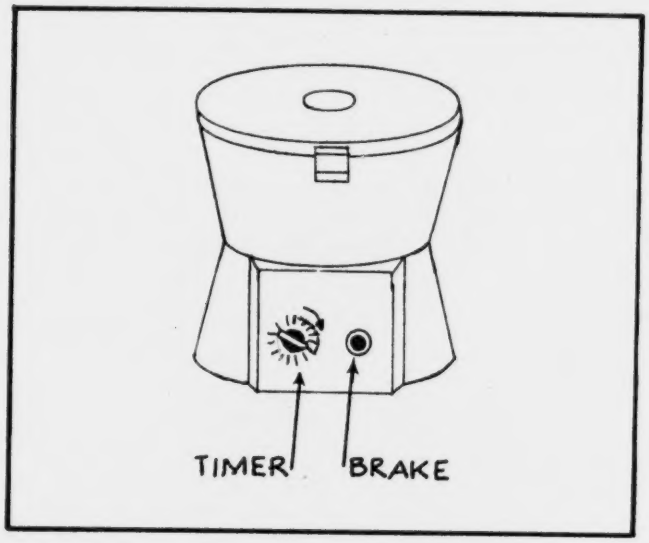


(4) Check the microhematocrit centrifuge to see that it is firmly in place. It is usually held to the table by suction cups. If loose, apply a few drops of oil to each cup, then force the centrifuge down so that a firm suction is created. You will find that the use of oil makes a better suction seal than water.



(5) Rotate the timer dial <u>past</u> "5 minutes" and then return the pointer to "5 minutes." This turns the centrifuge on and it will stop automatically after running for five minutes.

In different laboratories the period of time varies from 3 to 5 minutes. Use the time indicated in the hematology manual.



While the centrifuge is on, do not cover or block the holes which allow the air to escape from the inside. Watch the centrifuge for a few seconds while it is in operation. If it "walks" (moves) across the table, stop it by turning the timer dial to "0" and applying the brake, if one is present. Apply the brake repeatedly (alternately on and off) until the rotating head stops. Re-oil the suction caps (or remove excess oil) and repeat Step (4). If the centrifuge moves again, consult the instructor.

(6) Let the centrifuge head stop by itself. If the rotating head is stopped suddenly, the red cells can become dislodged or loosened and inaccurate high readings may result.

Never open the cover when the head is spinning. This can be extremely dangerous.

(7) After the centrifuge has stopped, unlock and lift the lid.

(8) Loosen the cover (using the attached wrench if necessary) and lift off.

(9) Observe each capillary tube:

If a tube is missing, it probably became dislodged or was not placed in the groove correctly, and shattered.

If a tube is empty or less than two-thirds full, the seal leaked.

In either instance, the test must be repeated.

C. Determining the Value of the Microhematocrit

After centrifuging, you should repeat the procedure if:

(1) a tube is missing (it has shattered);

(2) the plasma layer is hemolyzed (red in color)--in this case, a new blood sample must be obtained;

(3) a tube is only half full--this creates doubt as to whether leakage has occurred;

(4) the tube is completely empty (it has leaked).

Therefore, the following habits should be developed to help you obtain accurate results:

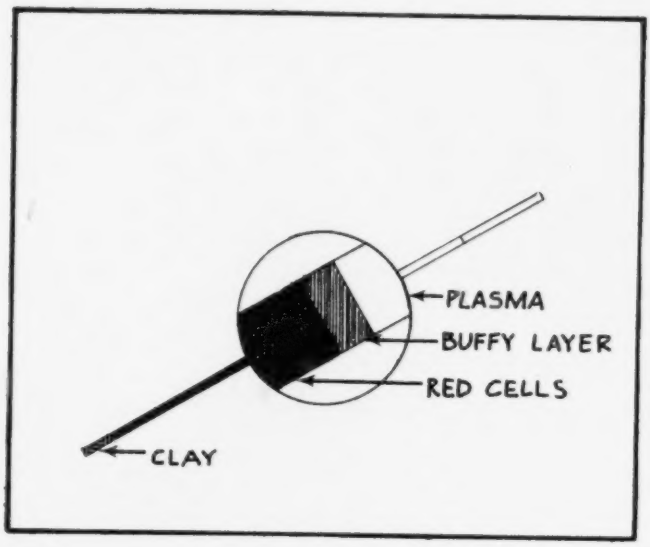
(1) Always be consistent in filling a capillary tube; fill every tube two-thirds full. A capillary tube that is less full after centrifuging is evidence of leakage.

(2) Run all hematocrit tests in duplicate; they should agree within a 1% reading value.

(3) Compare the hematocrit results with the hemoglobin findings and calculate the MCHC. This number should be within certain limits. See Enrichment Section E for more details regarding this check.

Introduction

During centrifugation, the heaviest group of cells, the red blood cells (RBC), have become packed to the bottom of the capillary tube. The next heaviest group of cells, the white blood cells (WBC) and platelets (thrombocytes), appear as a narrow white band and are packed on top of the red cells to form what is known as the buffy layer or buffy coat. The lightest material, the plasma, is above all these.



In the instructions that follow, do not include the buffy layer in your readings.

Calculating the hematocrit requires that two capillary tube measurements be taken: the length of the red cell layer and the length of the total blood sample.

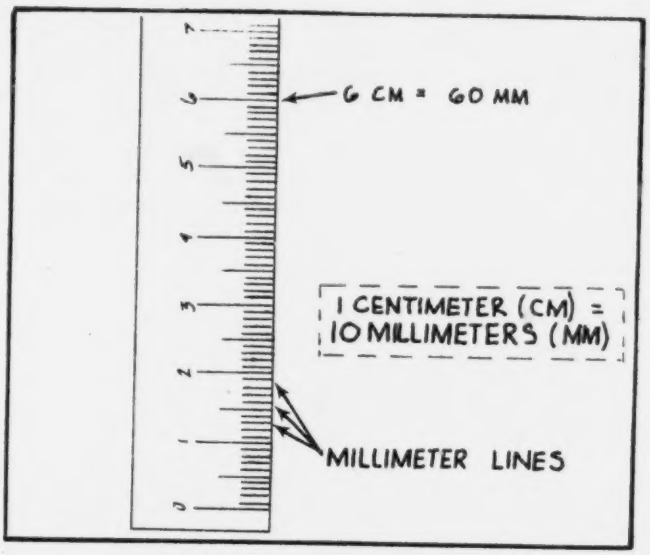
One calculation will be made, the percent of the red blood cells in the total sample.

These measurements and calculations resulting in the hematocrit determination can be accomplished by using a ruler or by using one of the many microhematocrit readers on which the answer is easily read after a couple of simple

manipulations (no measurements or calculations are necessary). The more difficult method (with the use of a ruler) will be shown in this lesson because a microhematocrit reader may be broken or misplaced. Procedures for using one microhematocrit reader and descriptions of four others are included in the Enrichment Section.

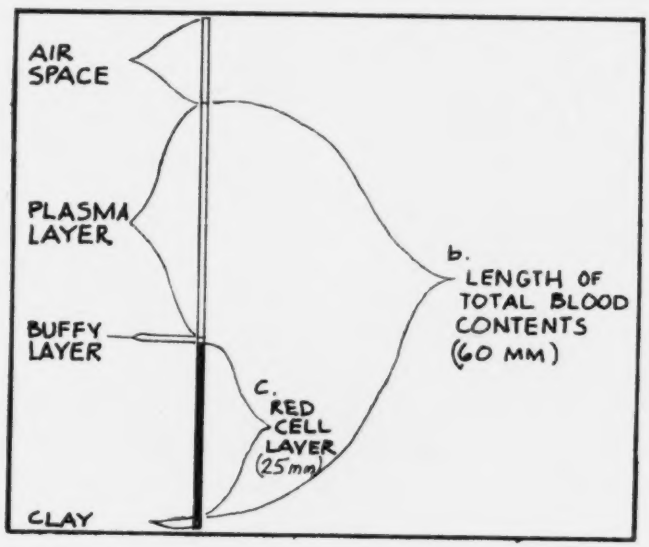
(1) Obtain a small ruler, calibrated in millimeters (mm).

See illustration opposite for exact measurements of millimeters and centimeters, to prevent mistakes.



(2) Measure in millimeters (mm) the entire length of the blood contents of the tube (the plasma liquid, the buffy layer, and the red cells).

(3) Measure in millimeters the length of the red cell layer.



(4) Calculate as follows:

$$\frac{\text{Length of red cell layer}}{\text{Length of total contents}} \times 100 = \text{Hematocrit value}$$

This is the same as:

$$\frac{\text{Step c}}{\text{Step b}} \times 100$$

(5) In this case:

Length of RBC layer = 25 mm.
Length of total contents = 60 mm.

Hematocrit = $\frac{25}{60}$ X 100 = 41.7 volume percent

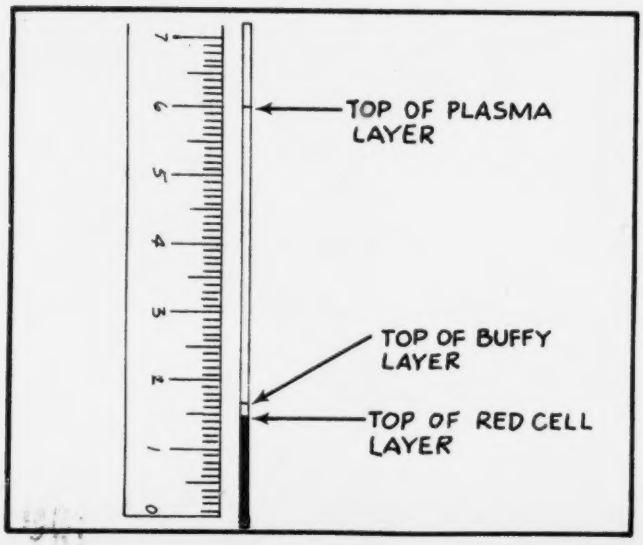
The hematocrit would be reported as 42 vol. % or 42% because the answer is considered accurate to the nearest whole percent.

D. Case Study: Determining a Microhematocrit Reading

A 52 year old man entered the hospital with a bleeding ulcer. An emergency hematocrit was ordered by his doctor. A capillary tube was filled, sealed and centrifuged.

Calculate the hematocrit from the actual size picture below.

Work Area
(Show calculations here)



Answer = _____ vol. %.
See following page for confirmation of your answer.

Confirmation of Hematocrit Calculations

Set-up:

$$\text{Hematocrit (vol. \%)} = \frac{15 \text{ mm}}{60 \text{ mm}} \times 100$$

Answer: Hematocrit = 25 vol. %

PERFORMANCE TEST

For the satisfactory completion of this lesson you will be required to:

1. Two-thirds fill a capillary tube with blood from a properly mixed blood sample.

2. Seal the capillary tube with clay.

3. Centrifuge the capillary tube blood sample.

4. Calculate the hematocrit reading using a millimeter.

5. Discuss reasons for performing each step of this procedure.

When you are ready to demonstrate your ability to complete the above objectives, ask your instructor to initial the blank below, and he will then administer the performance test, which is based on the Performance Checklist (see next page).

Instructor's Check No. 1: _____
Initials

PERFORMANCE CHECKLIST

Unit: The Hematocrit Procedure

Student: _____

School or Facility: _____

Date: _____

	SATISFACTORY	UNSATISFACTORY	NOT APPLICABLE	NOT OBSERVED
1. Selected proper capillary tube.				
2. Mixed sample of blood by slowly inverting 10 to 15 times.				
3. Removed stopper from blood sample with no spattering.				
4. Filled capillary tube two-thirds full with blood without contaminating other end.				
5. Tilted capillary tube so both ends were free of blood.				
6. Removed excess blood from outside of tube with only a downward motion.				
7. Sealed blue-tip end with sealing clay and without blood reaching opposite tip.				
8. Checked microhematocrit centrifuge before using:				
a. Had a good suction holding it to bench top.				
b. Examined rubber liner, and rotated or replaced it if necessary.				
9. Placed sample correctly into groove in head of centrifuge with sealed tip against liner.				
10. Operated microhematocrit centrifuge correctly:				
a. Replaced cover.				
b. Closed and locked lid.				
c. Manipulated timer properly; turned it past 5 minutes and then set correct time.				
d. Allowed head to come to a full stop by itself.				
e. Removed sample without breaking or mixing contents.				
11. Measured red cell and total portions of the sample correctly.				
-CONTINUED-				

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PERFORMANCE CHECKLIST

Unit: The Hematocrit Procedure (Continued)

Student: _____

School or Facility: _____

Date: _____

	SATISFACTORY	UNSATISFACTORY	NOT APPLICABLE	NOT OBSERVED
12. Calculated the results, gave the correct value within ± 2%.				
13. Completed task within time limit set by instructor.				

Instructor: _____ Performance Check Time: _____

Comments: _____

_____

Trial No. 1: *Pass_____ Unsatisfactory_____

Trial No. 2: *Pass_____ Unsatisfactory_____

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* Must have 100% satisfactory performance

PART III: ENRICHMENT

A. THE MACROHEMATOCRIT (WINTROBE METHOD)

1. Introduction

The macrotechnique of determining the hematocrit makes use of the Wintrobe hematocrit tube. The Wintrobe tube is approximately four inches long. It is calibrated from bottom to top in 100 divisions. Major calibrations are numbered from 0 to 10, the numbers decreasing in value on one side from top to bottom and increasing from top to bottom on the other side of the calibration marks. The numbers that increase from the bottom to top are used in the determination of the macrohematocrit. The other set of numbers is for a procedure known as a Sedimentation Rate, which will be presented in another lesson.

2. Materials and Equipment

a. Whole blood sample (with anticoagulant).

b. Filler pipet with bulb (Pasteur pipet).

c. Tissue or gauze (2 by 2 inches).

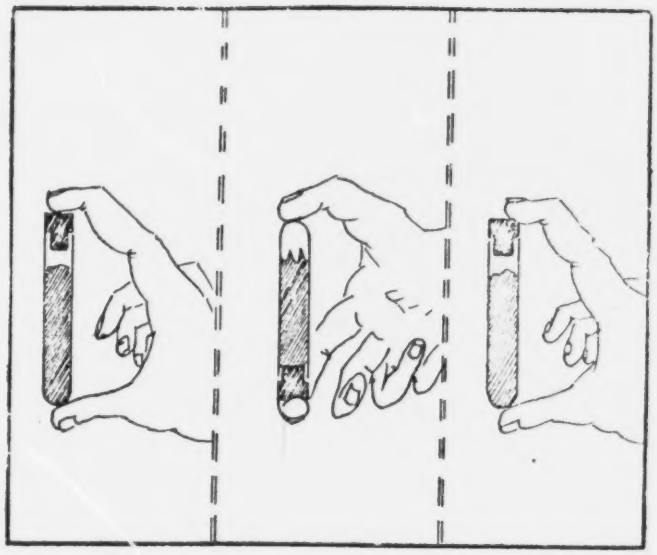
d. Wintrobe tube.

e. Wintrobe tube rack (or another tube holder).

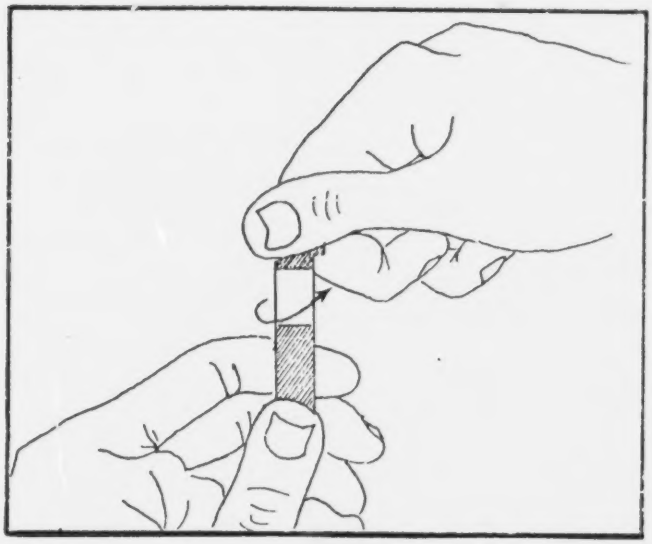
f. Centrifuge, large (floor model preferred).

3. Procedure: The Wintrobe Method

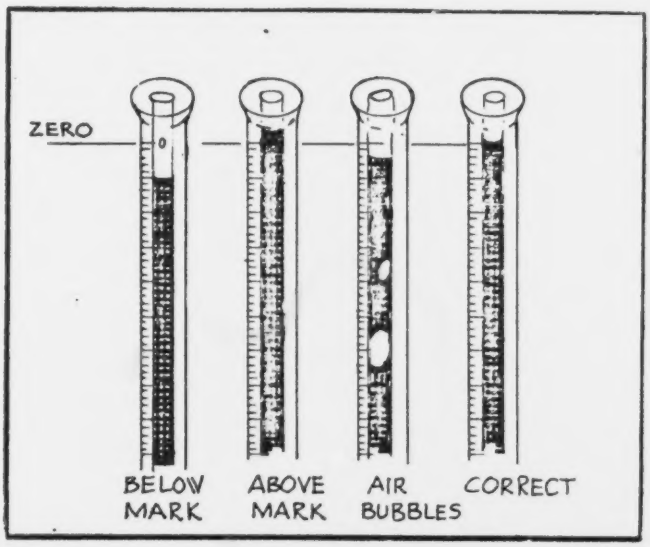
Some laboratories use a disposable Wintrobe tube, one that can be thrown away after completion of the test.



a. Mix the oxalated whole blood sample gently by inversion 10 to 15 times. A mechanical rotator can be used.



b. Remove the stopper carefully in the manner described previously (or repeat these directions as given for the microhematocrit).



c. Fill the Wintrobe tube to the zero mark. Be sure that the top of the column of blood is level with this mark.

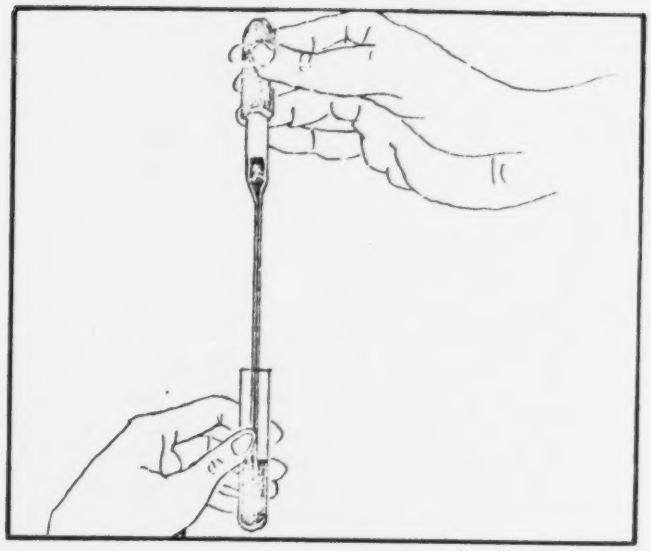
It takes practice to fill the Wintrobe tube properly. If it is done wrong, air can get trapped within the column of blood, or the level of blood may be below or above the zero.

To fill the Wintrobe tube:

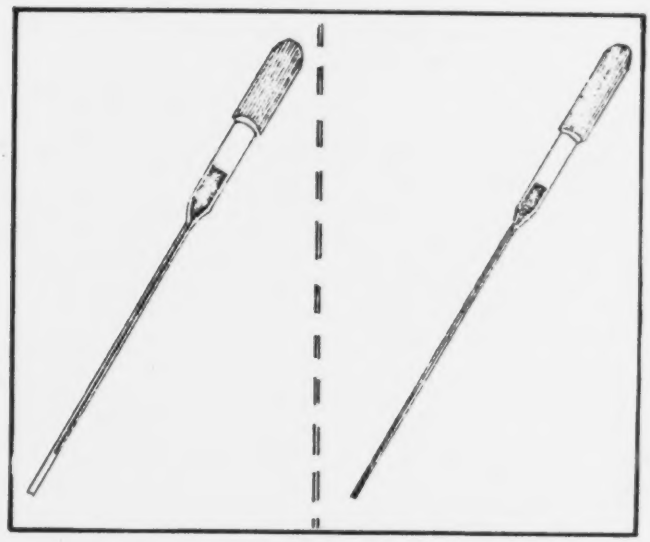
(1) Expel air from a clean, dry filler pipet (Pasteur pipet) by pinching the bulb.

(2) Insert the end of the pipet into the tube of <u>mixed</u> blood.

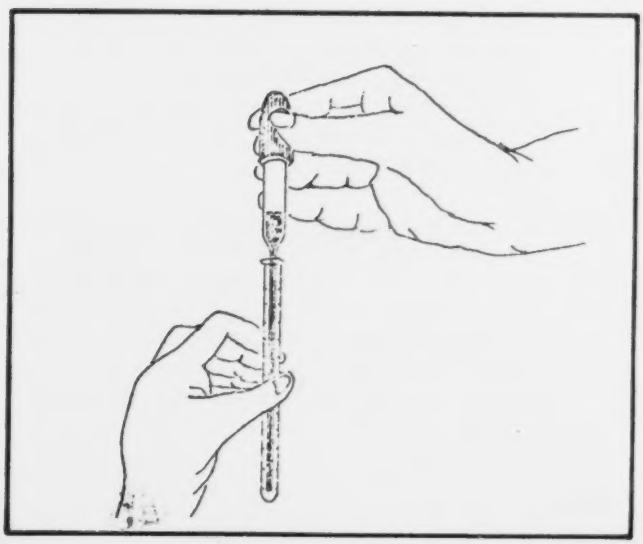
(3) Release pressure on bulb to withdraw enough to half-fill the pipet. Do <u>not</u> allow blood to enter the rubber bulb as this will contaminate the next specimens.



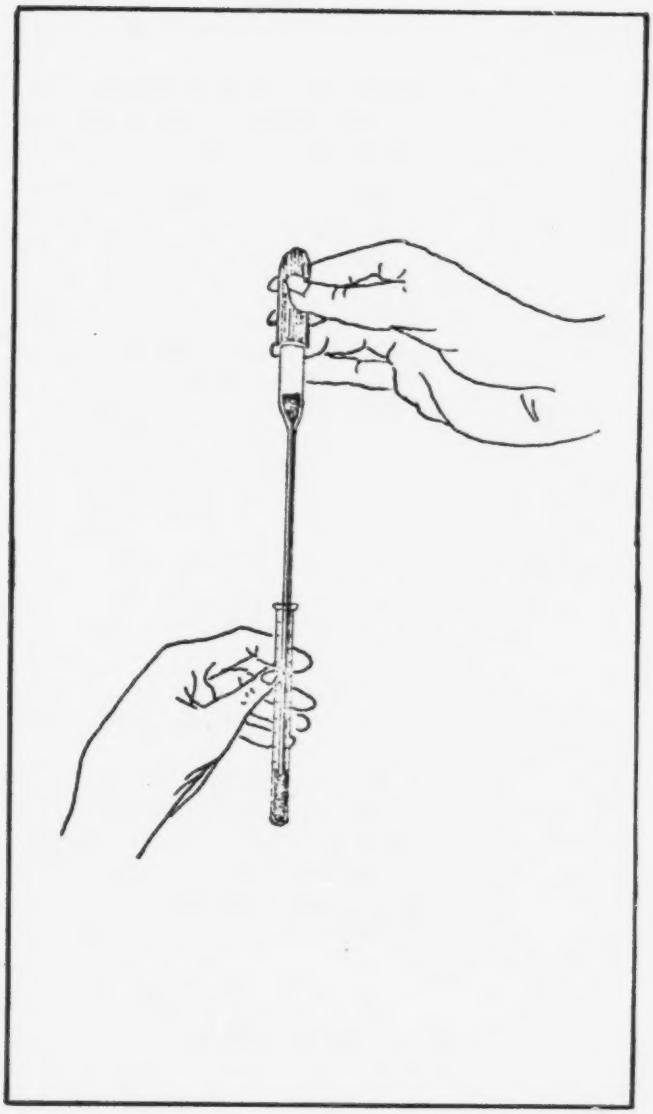
(4) Press the bulb again to force the blood to the tip of the pipet. There should be <u>no</u> air space below the blood in the tip.



(5) With the blood held in the tip by slight bulb pressure, place the tip of the filler pipet all the way to the bottom of the bore of the Wintrobe tube.



(6) While applying just enough pressure to force a slow release of blood, squeeze the bulb slowly and pull the pipet up slowly. Keep the tip of the pipet just below the surface of the blood.



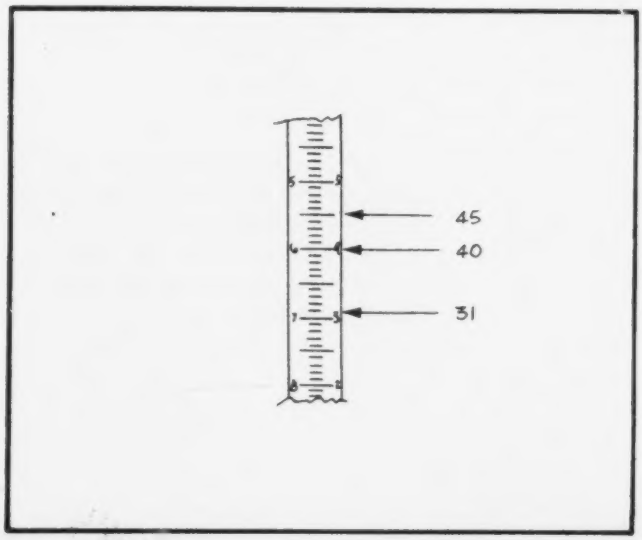
d. Place the adapter into the centrifuge shield, then insert the Wintrobe tube. Be sure the centrifuge is balanced. An empty Wintrobe tube is a satisfactory balance (see lesson on separating clinical specimens).

e. Centrifuge the sample for 30 minutes at 3,000 rpm.

f. Remove the sample from the centrifuge. Be careful not to disturb the layer of packed red blood cells.

g. Determine the hematocrit value, using the calibrated scale that <u>increases</u> from bottom to top. Read the number that is level with the top of the red cell layer. Ignore the buffy layer.

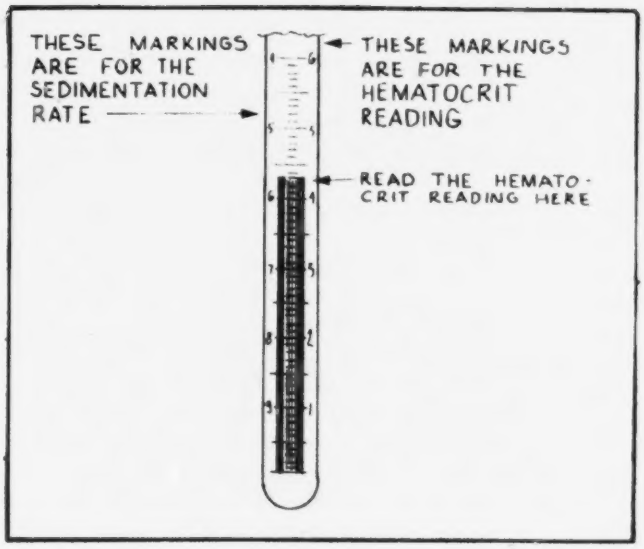
Each number corresponds to a unit of 10. That is, 3 = 30, 4 = 40, 5 = 50, and so on. The smaller calibration marks represent single units of one. Examples of reading the hematocrit from the Wintrobe tube are presented in the opposite diagram.



In the illustration to the right,

the hematocrit is _____ vol. %.

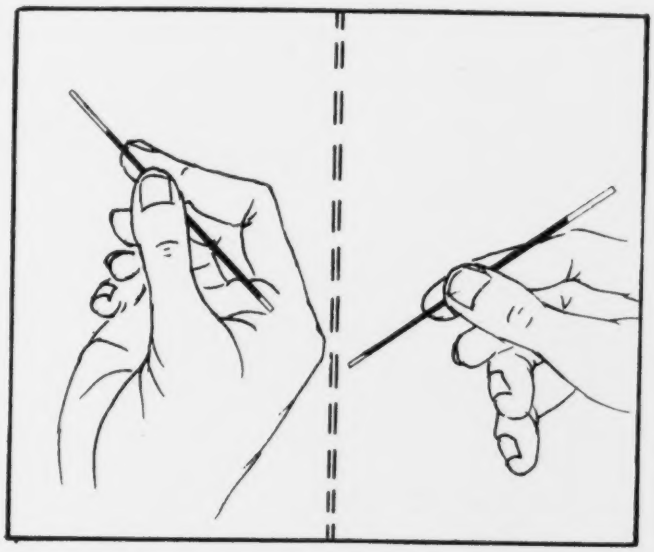
See the next page for confirmation of your answer.


THESE MARKINGS ARE FOR THE SEDIMENTATION RATE
THESE MARKINGS ARE FOR THE HEMATOCRIT READING
READ THE HEMATOCRIT READING HERE

B. WHEN TO USE THE RED-TIP CAPILLARY TUBE

Sometimes the microhematocrit determination is performed directly from capillary blood. A good, deep puncture of the skin is made, generally near the tip of the index finger. The first two drops of blood are wiped away and then a heparinized (red tip) capillary tube is filled by capillary action. A more thorough presentation of this technique appears in the lesson on drawing capillary blood.

Since the blood will clot if not completely mixed with the dried heparin, it must be mixed immediately upon collection, otherwise readings will be high. This is done by holding the capillary tube horizontally and then slightly tilting one end lower than the other. This is then repeated the other way. By this means, the blood will move back and forth and mix with the heparin. Do not let the blood come too close to either end of the tube as this could prevent a good seal.



The required amount of blood, sealing the tube, centrifugation, and hematocrit calculation are the same as described in the previous section of this module (see page 24 through 33).

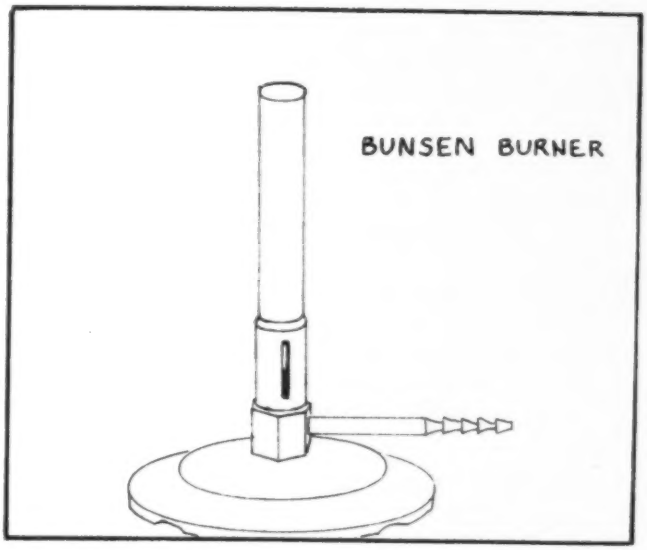
Confirmation of Answer

The hematocrit determination = 43 vol. %

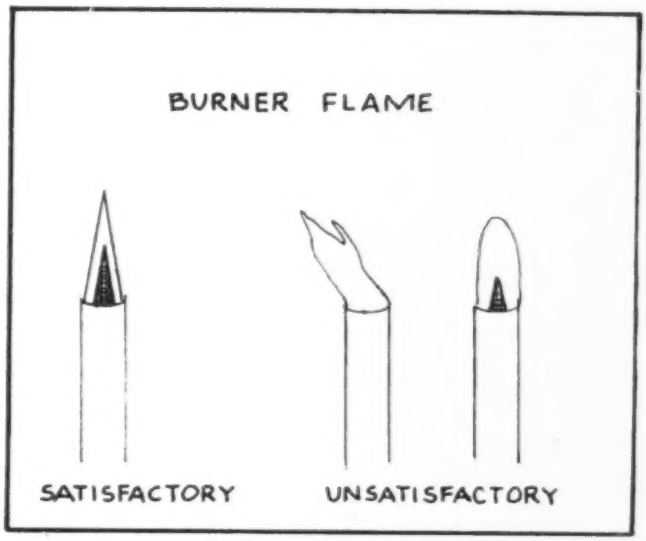
C. SEALING A CAPILLARY TUBE WITH A GAS BURNER

Introduction

There are several Bunsen or gas burners and the one preferred for sealing a capillary tube is illustrated opposite. The narrower the flame in width and the finer the point of the flame, the easier it is to accomplish the sealing. A special attachment (wing tip) is available that creates a very fine flame; however, it is best that you learn to produce a good seal without the attachment, which is not available everywhere. It will take practice to develop good sealing technique; however, the results are worth the effort. Remember this fact: it is possible for the laboratory to run out of clay but there will always be a burner available.

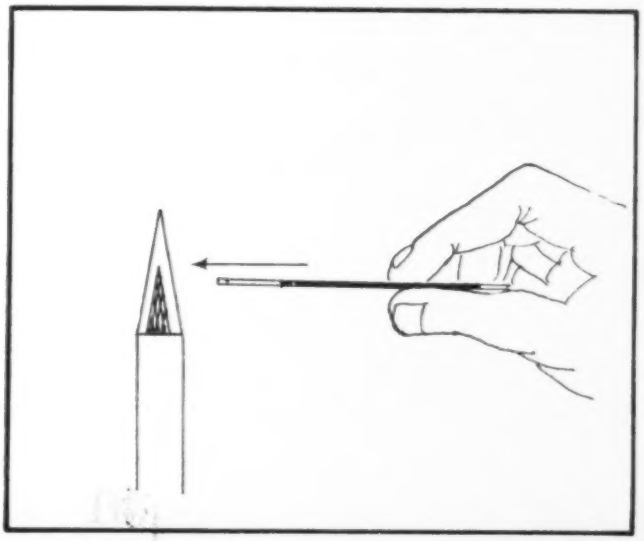


1. Adjust the flame so that it is short and comes to a point. The inner cone of the flame will be used and this must be visible and large enough in size. Adjust the gas burner accordingly. (See the lesson on use of the gas burner.) Do not use a flame that jumps around or bends. Avoid drafts caused by air currents from open doors and windows and any movements which will interfere with the stability of the flame.



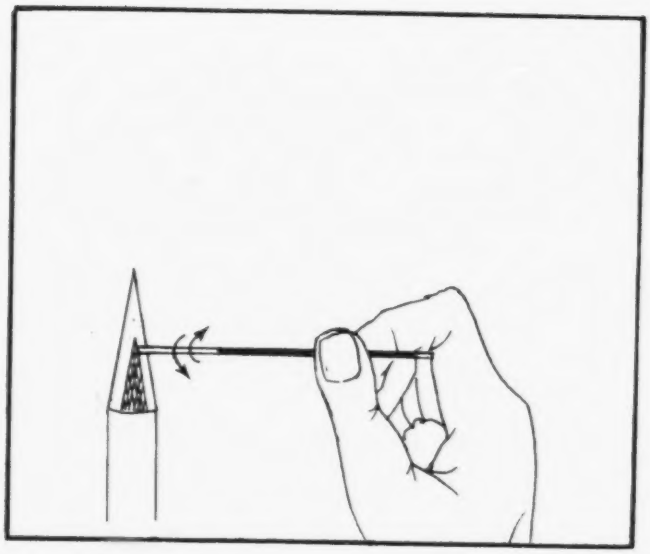
3. Hold the capillary tube in a horizontal position, with the colored tip towards the flame. The tube must be held with the thumb and index finger near the plain end (away from the flame), in such a manner that the plain end is not hidden from view.

   The plain end must be constantly in view during sealing so that you can prevent blood from moving towards the end away from the flame and leaking out. Removing the tube from the flame for a moment will stop this movement of blood.

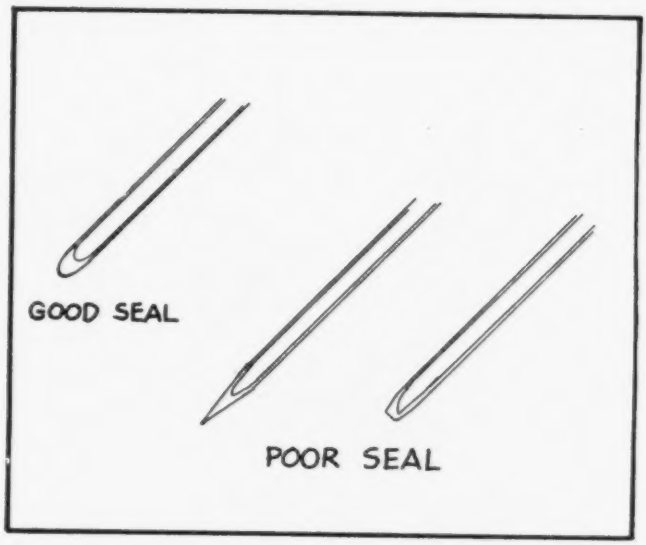


3. While twisting the tube back and forth, place it into the tip of the BLUE flame. While still rotating the tube, leave it suspended there for only a few seconds and then remove. Examine the seal and repeat this procedure if necessary.

CAUTION: Glass remains hot for a few seconds; therefore, do not touch the flamed end of the capillary tube or place it on a non-heatproof or cold surface.



NOTE: A perfect seal will have made a rounded bottom on the capillary tube. The glass will have fused together inside from the tip up to a distance of about 3 to 5 mm. Equally important, the bore will have rounded off. Unless this is so, the seal is no good and another attempt must be made with a new sample. Examine the illustration carefully to compare your result.



a. The heat of the flame will make the blood move toward the opposite tip. Excess heat will cause the blood to shoot out of this end.

b. Any blood that is present in the third of the capillary tube nearest the flame, including the colored tip, can get "cooked" and the test will be invalidated. The part of the tube containing the blood must not even be allowed to get warm.

c. An inaccurate test reading will result if there is <u>not</u> a perfect seal.

d. There is no way of knowing if the seal is complete until after the specimen is centrifuged. If the seal is imperfect, blood will be forced out. Valuable time can be wasted if this turns out to be the case.

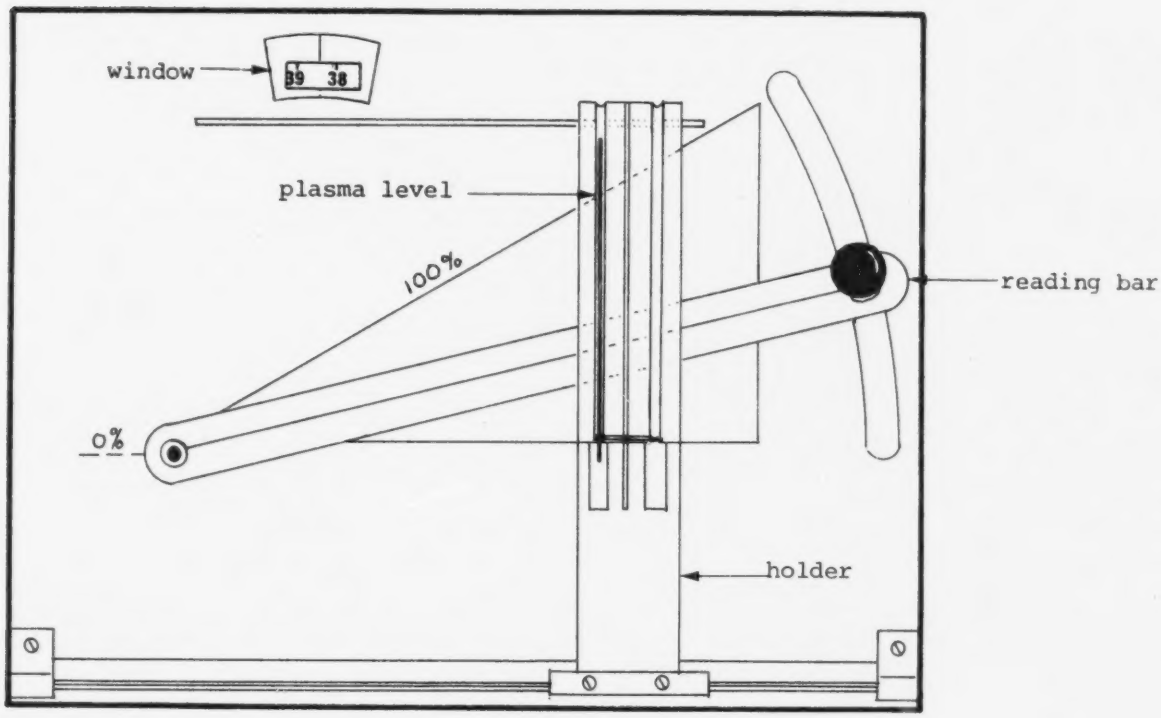
D. ALTERNATE METHODS OF CALCULATING THE MICROHEMATOCRIT

1. Hematocrit Tube Reader, Adams

Introduction:

This instrument is a precision mechanical reader that is accurate, fast, and easy to operate. The hematocrit value appears as a large, distinct number. Capillary tubes in sizes from 32 mm to 75 mm are inserted into the holder.

Procedure:



1. Insert the centrifuged capillary blood tube in the plastic holder.

2. Move the capillary tube vertically (up or down) in the holder until the boundary (line that joins) between the red blood cell layer and the clay coincides with (rests on) the 0% line (base of triangle).

3. Move the holder horizontally (left or right) until the top (meniscus) of the plasma level coincides with the 100% line (upper edge of the triangle).

4. Grasp the black knob on the reading bar and move it up or down until the black line on the reading bar coincides with the boundary line between the red blood cell and the buffy (white) layers.

   If the buffy layer is not visible (this occurs in some normal and below-normal white blood cell specimens), use the boundary line between the red blood cell and plasma layers.

5. Read the hematocrit determination in the window at the upper left. The hematocrit determination illustrated is 38.3 vol. %.

6. Report the hematocrit determination to the nearest whole volume %. The hematocrit determination in the illustrated example would be reported as 38 vol. %.

2. Microhematocrit Tube Reader Card

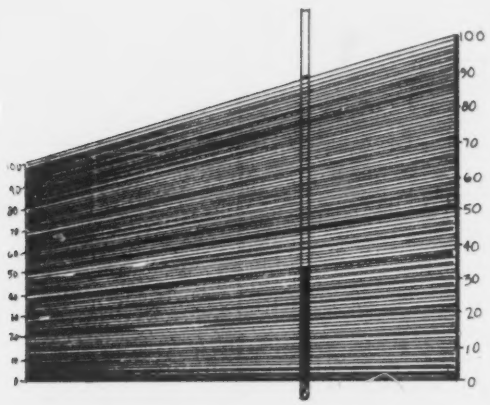
Procedure:

1. Place the hematocrit tube on the card (see illustration below). Move the tube to the left or right until the top line (showing 100%) is at the top of the plasma and the bottom line (showing 0%) is at the bottom of the packed red cells.

2. Find the line closest to where the plasma and red cell layers meet.

   A so-called "buffy layer" usually is visible at the top of the packed red cells. This is composed of the white cells and platelets present in the sample. When making the second reading, the line must be at the top of the red cells, not at the top of this buffy layer.

3. Follow this line to the side of the card and read the given value. This is the hematocrit determination. The illustrated hematocrit determination is 38 vol. %.



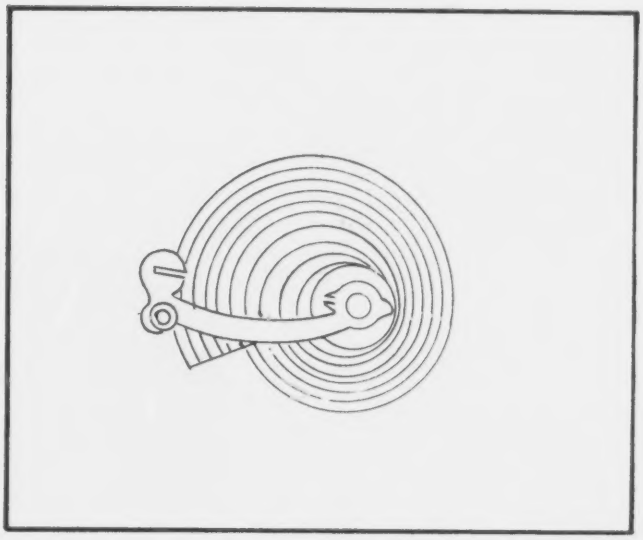
Microhematocrit Tube Reader Card

3. Other Microhematocrit Readers

There are several other microhematocrit readers that are used by some laboratories. These are illustrated and described here but the step by step procedures for using them are not discussed. Clinical laboratories generally maintain their own procedure manuals to describe their use.

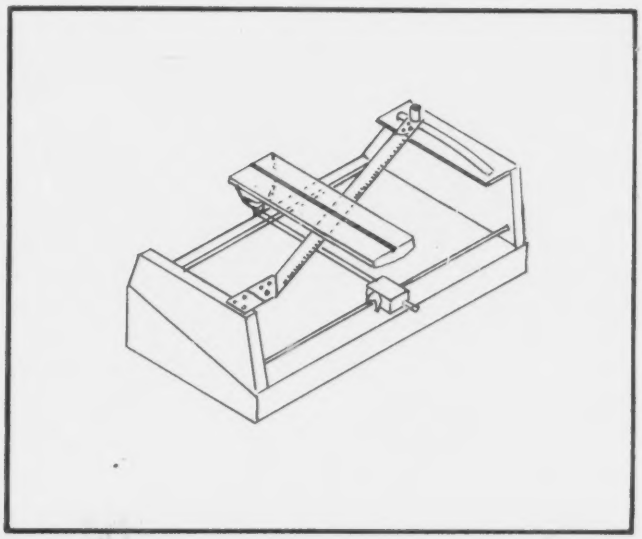
Hematocrit Tube, "Spiracrit" Reader

An easy-to-use, highly accurate microhematocrit reading device. Capillary tube is simply inserted in the slots of the revolving plastic arm so that the base of the cell layer coincides with the red "0" line. The handle is turned until the meniscus of the plasma coincides with the "100" line. Volume of cells is read directly in percent.



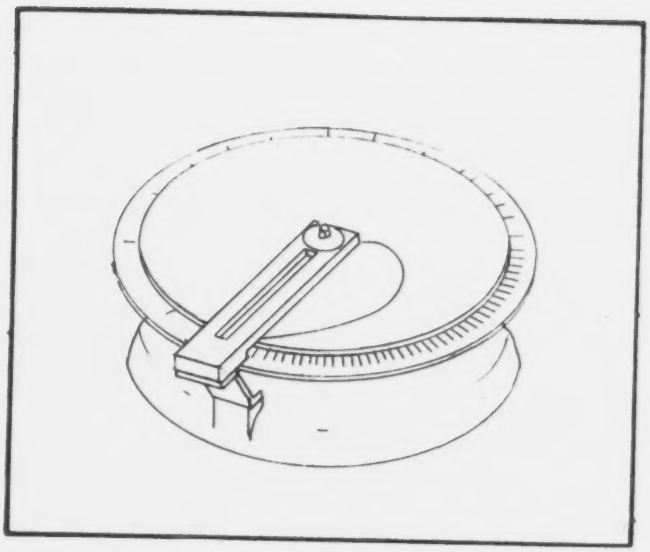
Capillary Tube Reader, International Model CR

For direct reading of capillary tubes used in hematocrit determinations. Consists of a capillary tube holder designed to accommodate various length tubes, and a direct reading ruler graduated in 1% divisions, mounted in a die-cast metal housing. A magnifier, with flip-out hinge, is placed above the tube to facilitate readings. Eight-watt fluorescent lights fitted into the base provide adequate illumination. Overall dimensions are 6-1/2 ins. by 15-1/2 ins. by 6 ins. high. The devices comes complete with 6-ft. cord and plug.



Micro-Capillary Reader,
International

Designed to facilitate the reading of micro-capillary tubes being used for hematocrit determinations. The reader minimizes errors since serum-air interface and red cell-white cell interface are successively aligned with a single spiral line engraved in a stainless steel plate. The centrifuged capillary tube is placed in the groove of the plastic indicator. Upon completion of alignment, the percent red cells is read directly from an expanded 24-in. scale graduated from 1 to 100% in 1% divisions.



E. MEAN CORPUSCULAR HEMOGLOBIN CONTENTRATION (MCHC)

The discovery of a relationship between the hematocrit determination (packed red blood cell volume) and the hemoglobin test (amount of hemoglobin [red coloring matter] in the blood) enabled such hematologists as Wintrobe to introduce a procedure called the mean corpuscular hemoglobin concentration, abbreviated MCHC.

The MCHC is the average hemoglobin concentration per 100 ml of packed red cells in percent. It represents the amount of hemoglobin in the average red blood cell (RBC). In quantitative terms:

$$\text{MCHC} = \frac{\text{hemoglobin (grams/100 ml)}}{\text{hematocrit (volume \%)}} \times 100.$$

The normal MCHC range is 32 to 36 g/100 ml (or g %). This index provides a good check on the accuracy of the hematocrit (and hemoglobin) determination.

If the MCHC is low (less than 30 mg/100 ml), the average red blood cell should be abnormally small (microcytic), lacking in hemoglobin (hypochromic), or both. If none of these conditions exist, there is a good possibility that an error has been made in the hematocrit (or hemoglobin) procedure. Therefore, the determinations should be rechecked, and a fresh blood sample drawn if necessary.

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Lynch, Matthew J., et al. Medical Laboratory Technology, 2nd ed. Philadelphia: W. B. Saunders Co., 1969, pp. 672-73.

Maher, David J. Medical Technology, 6th ed. Berkeley, Calif.: Berkeley Scientific Publications, 1968, p. 241.

Platt, William R. Color Atlas and Textbook of Hematology. Philadelphia: J. B. Lippincott Co., 1969, pp. 60-63.

Seiverd, Charles E. Hematology for Medical Technologists, 3rd ed. Philadelphia: Lea and Febiger, 1964, pp. 289-98.

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APPENDIX A

CLINICAL LABORATORY OCCUPATIONS
CONTENT OUTLINE

STAGE I CURRICULUM: FUNDAMENTAL SKILLS IN THE CLINICAL LABORATORY

Unit 1: Specimen Processing (11 modules)

Unit 2: Inventory of Supplies (1 module)

Unit 3: Introduction to Clinical Measurements (11 modules)

STAGE II CURRICULUM: INTRODUCTION TO THE CLINICAL LABORATORY SECTIONS

Unit 1: Introduction to Microbiology (9 modules)

Unit 2: Introduction to Clinical Chemistry (2 modules)

Unit 3: Introduction to Serology (19 modules)

Unit 4: Introduction to Urinalysis (4 modules)

Unit 5: Introduction to Hematology (10 modules)

EXPANDED CONTENT OUTLINE
CLINICAL LABORATORY OCCUPATIONS

STAGE I CURRICULUM: FUNDAMENTAL SKILLS IN THE CLINICAL LABORATORY

- Unit 1: Specimen Processing (Completed)
  - Sub-Unit: Drawing Blood
    - Module: Drawing Venous Blood
    - Module: Drawing Capillary Blood
  - Sub-Unit: Collecting Clinical Specimens
    - Module: Preparing a Thick and a Thin Blood Smear
    - Module: Collecting Blood for Microbiological Examination
    - Module: Collecting Urine
    - Module: Collecting Other Clinical Specimens
  - Sub-Unit: Handling Clinical Specimens
    - Module: Labeling Clinical Specimens
    - Module: Distributing Clinical Specimens
    - Module: Logging Clinical Specimens
    - Module: Separating Clinical Specimens
    - Module: Preparing Clinical Specimens for Mailing
- Unit 2: Inventory of Supplies (Completed)
  - Module: Taking an Inventory
- Unit 3: Introduction to Clinical Measurement (In process)
  - Sub-Unit: Measuring Volumes
    - Module: Cleaning Laboratory Glassware
    - Module: Using Beakers and Flasks
    - Module: Using Graduates
    - Module: Preparing Solutions
    - Module: Using Pipets
    - Module: Calibrating Medicine Droppers
    - Module: Calculations for Preparing Percent Solutions
    - Module: Calculations for Preparing Molar Solutions
  - Sub-Unit: Weighing
    - Module: Adjusting and Zeroing the Balance
    - Module: Weighing with a Balance
    - Module: Determining the Sensitivity of the Balance

STAGE II CURRICULUM: INTRODUCTION TO THE CLINICAL LABORATORY SECTIONS

- Unit 1: Introduction to Microbiology (In process)
  - Sub-Unit: Fundamental Stains in Microbiology (Completed)
    - Module: Using a Gas Burner
    - Module: Preparing Slides for Staining
    - Module: Gram Stain
    - Module: Acid-Fast Stain
    - Module: India Ink Preparation
    - Module: D'Antoni's Iodine Stain
    - Module: Giemsa's Stain
  - Sub-Unit: Bacteriological Media (In process)
    - Module: Preparing Media (In process)
    - Module: Inoculating a Plate and Tube (Completed)
- Unit 2: Introduction to Clinical Chemistry (In process)
  - Module: Performing a Chemical Assay (Completed)
  - Module: Introduction to Photometric Measurements (In process)

Unit 3: Introduction to Serology
- Sub-Unit: Serodiagnosis for Syphilis
  - Module: VDRL Test
- Sub-Unit: Other Serodiagnostic Tests - Agglutination Tests
  - Module: Brucella ("Febrile")
  - Module: Proteus ("Febrile")
  - Module: Salmonella ("Febrile")
  - Module: Leptospira
  - Module: Tularemia
  - Module: Toxoplasmin (Parasitic)
  - Module: Cold Agglutinins (Red Cell)
  - Module: Heterophile (Red Cell)
  - Module: Antithyroid Antibody or TA Test (Latex)
  - Module: Rheumatoid Arthritis or RA Test (Latex)
  - Module: Antinuclear Antibody or LE Test or ANA Test (Latex)
  - Module: Coccidioidomycosis Antibody or CM Test (Latex)
- Sub-Unit: Other Serodiagnostic Tests - Precipitin Test
  - Module: C-Reactive Protein
- Sub-Unit: Other Serodiagnostic Tests - Immunodiffusion Tests
  - Module: Immunodiffusion Complement Fixation Tests or IDCF Test (Coccidioidomycosis)
  - Module: Immunodiffusion Plate for Assay of Human Complement or C'3 (B_{1c}/B_{1a} Globulin)
  - Module: Fetal Hemoglobin (Fetotest)
- Sub-Unit: Toxin-Antibody Test
  - Module: Antistreptolysin O Titer or ASO Test
- Sub-Unit: Other Tests
  - Module: Colloidal Gold

Unit 4: Introduction to Urinalysis
- Module: Urine Character
- Module: Specific Gravity
- Module: pH and Individual Biochemical Tests
- Module: Dip-Stick Methods

Unit 5: Introduction to Hematology
- Module: The Hematocrit
- Module: Hemoglobin
- Module: White Blood Cell Count
- Module: Red Blood Cell Count
- Module: Platelet Count
- Module: Bleeding Time
- Module: Capillary Clotting Time
- Module: Venous Clotting Time
- Module: Sedimentation Rate
- Module: Reticulocyte Count

APPENDIX B

GENERAL INSTRUCTIONS TO STUDENTS TAKING PERFORMANCE TESTS

To test your ability to apply the skills that you have learned, you will be asked to perform various tasks under conditions similar to those you would find on the job in a laboratory. When you take these tests, remember that preparation and follow-up may be as necessary as "doing" the procedure. You should do all the things that you would do if you were performing the tasks on the job, and you should use the techniques that you would employ if you were on the job in a health agency.

Listen to and/or read the test instructions carefully. Recall what it is you need to perform the task. The items you will need will be available, but you may have to pick them out yourself. Recall what the proper techniques are. If the instructions say anything about the circumstances or the condition of the patient, consider how this may affect the way in which you perform the task. Make sure that you do not omit any of the necessary steps in performance of a task. Before you indicate to the instructor that you have finished, ask yourself if you have completed all the follow-up activities that normally would be necessary if you were actually on the job.

Some of the tests may have time limits, because on the job you would be expected to practice economy of time as far as it is consistent with effective performance of your duties. The time limits are reasonable ones. They are not set with the intention of seeing how fast you can perform a task, but only to check your ability to perform efficiently. Exceeding the time limit will lower your total score, but it will <u>not</u> cause you to receive an unsatisfactory rating as long as your performance is satisfactory in other respects.

An unsatisfactory rating does <u>not</u> mean that you have failed. It means that there is a deficiency (incorrect or imcomplete performance) in one or more activities in the procedure. The instructor will discuss with you the reason(s) for the unsatisfactory mark, after which you will review the material or practice the procedure until you feel prepared to repeat the performance test.

APPENDIX C

STUDENT MODULE EVALUATION FORM

UCLA Allied Health Professions Project
Clinical Laboratory Occupations

NAME _____ DATE _____

SCHOOL _____

MODULE NO. AND TITLE _____

Most items will require only a check mark (✓) to give your answer. Please answer all items accurately. Thank you for your help on this important study.

NOTE: YOU MAY CHECK MORE THAN ONE ANSWER.

1. Please indicate, to the closest 1/2 hour, the total time it took you to complete this module.

1/2 hr.	1 hr.	1-1/2 hrs.	2 hrs.	2-1/2 hrs.	3 hrs.	3-1/2 hrs.	4 hrs.
☐	☐	☐	☐	☐	☐	☐	☐

If more than 4 hours, how long? _____

2. What statements describe the activities in this module?

- ☐ Interesting
- ☐ Easy
- ☐ Hard
- ☐ Fun
- ☐ Too much reading
- ☐ Useful
- ☐ Too much theory

3. Describe the help you received on the module.

- ☐ I received no help. (Go to No. 5)
- ☐ I didn't need help.
- ☐ I received help from another student. (Go to No. 4)
- ☐ I received help from my instructor. (Go to No. 4)
- ☐ I received help from others. (Go to No. 4)

4. If you needed help - why?

- ☐ I was unable to understand what I was to do.
- ☐ The terms were too difficult.
- ☐ It did not cover what was to be learned.
- ☐ The objectives did not explain what was to be learned.
- ☐ The activities were too difficult.
- ☐ I needed help to locate materials, or tools, or aids, etc.

5. How might we change or improve the module? (Please make detailed comments, citing specific page numbers, on the back of this form.)

APPENDIX D

INSTRUCTOR MODULE EVALUATION FORM

UCLA Allied Health Professions Project
Clinical Laboratory Occupations

NAME_____ DATE_____

SCHOOL_____

MODULE TITLE AND NO._____

This form is designed to assist in identifying problems in learning and in performance evaluation. Most items will require only a check mark (✓) to give your answer. Please answer all items accurately. Your comments will be most valuable. Thank you for your help.

NOTE: YOU MAY CHECK MORE THAN ONE ANSWER

1. OVERALL EVALUATION

- ☐ Requires extensive teacher help.
- ☐ The typical student requires too long to complete the module.
- ☐ Reading level too difficult for my students.
- ☐ Please revise as indicated on the attached copy of the module.

2. TEACHING AIDS (Materials, Equipment, etc.)

- ☐ Acceptable.
- ☐ Requires too much teacher help.
- ☐ Too difficult for my students.
- ☐ Too difficult to obtain or prepare.

3. REVIEW QUESTIONS

- ☐ Acceptable.
- ☐ Too difficult for my students.
- ☐ Takes too long.
- ☐ Reading and words too difficult.
- ☐ Students dislike them.

4. LEARNER ACTIVITIES

- ☐ Acceptable.
- ☐ Activities not related to the objective, or they are irrelevant to overall development (point out on attached module).
- ☐ Activities require extensive teacher help.
- ☐ Too much reading required.
- ☐ Additional activities are needed. (Specify below.)
- ☐ Activities take too long to complete.
- ☐ There are too many activities.
- ☐ Revisions needed as indicated on attached module.

5. PERFORMANCE CHECKLISTS

- ☐ Acceptable.
- ☐ Too frequent.
- ☐ More needed as indicated on attached module.
- ☐ Needs to be written in simpler language. (Indicate vocabulary or structure causing difficulty.)
- ☐ Format is confusing - needed teacher explanation.
- ☐ Insufficient information is given in order to know what is intended. (Specify.)
- ☐ Too much reading - too much detail.
- ☐ Requires too much time for the student.
- ☐ Requires too much of the instructor's time.

For this module, from the total evaluation time recorded for the students you have checked (total Performance Check Time), compute the average time spent in evaluation of each student. _____

APPENDIX E

STUDENT BACKGROUND DATA
UCLA Allied Health Professions Project
Clinical Laboratory Occupations

Full name _____ Age _____ Sex _____

School or training facility _____

Check marital status: single _____ married _____ divorced _____

Father's occupation _____

Husband's occupation (if married woman _____

Check if you have a high school diploma: Yes _____ No _____

If not a high school graduate, give last school grade completed _____

Last high school attended:

name	city and state	dates (yrs.)
_____	_____	_____

Colleges attended:

_____	_____	_____
_____	_____	_____
name	city and state	dates (yrs.)

Employment (begin with present job if not a full-time student):

_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
kind of job	months on job	dates (yrs.)

If your experience includes work in a doctor's office or a clinical laboratory, briefly describe what your principal duties were:

_____

_____

_____

If you have ever taken any clinical laboratory courses, list the specific courses here:

		hours/week	number of weeks
name of course		hours/week	number of weeks

Describe the principal skills learned: _____

_____

What is your present vocational goal? (Indicate either the occupation you want to enter or a specific job position if you have one in mind.):

_____

If you have a different longer-range vocational goal, what is it? _____

_____

Your home address (include zip code if you know it): _____

_____

Name and address of a relative or other person who will know where to locate you if you move:

_____

_____

_____

_____

(We are asking for this information because we will want to contact you later to see what kind of employment you get and to ask you how effective you think this course has been in helping you toward reaching your vocational goals.)

APPENDIX F

STUDENT TEST RECORD
UCLA Allied Health Professions Project
Clinical Laboratory Occupations

Name of student _____

School or facility _____

List dates of administration and scores on any achievement, aptitude, personality, or other screening tests given to the student.

TEST	DATE	SCORE
GPA (high school)		
GPA (college)		
SAT - verbal		
SAT - mathematical		
WRAT		
SCAT		
Reading Comprehension (Stanine)		
Other		

APPENDIX G

INSTRUCTOR BACKGROUND DATA
UCLA Allied Health Professions Project

Name (Optional) _____ Age _____ Sex _____

Position title _____

School or facility _____

Check if you have a high school diploma: Yes _____ No _____

Number of years of college _____ College major _____

Highest college degree _____

Other diplomas, degrees, certificates, or awards _____

_____

Percentage of time currently devoted to teaching activities _____%

Number of years of teaching experience _____

Principal subject(s) taught _____

_____

Check types of institutions in which taught:

high school _____ jr. college _____ college _____ hospital _____ other _____

Check types of courses taught:

classroom lecture _____ laboratory _____ clinical _____

Number of years employed in present field of work _____

Check principal areas of activity during employment:

teaching _____ research _____ administration _____ clinical practice _____

Have you worked in a clinical laboratory? Yes _____ No _____

If yes, how many years? _____

In what capacities? _____

_____

APPENDIX H

INSTRUCTIONAL MATERIAL DEFICIENCY REPORT FORM

UCLA Allied Health Professions Project
Clinical Laboratory Occupations

MODULE TITLE AND NO._____

_____

DESCRIPTION OF DEFICIENCY OR LEARNING PROBLEM:

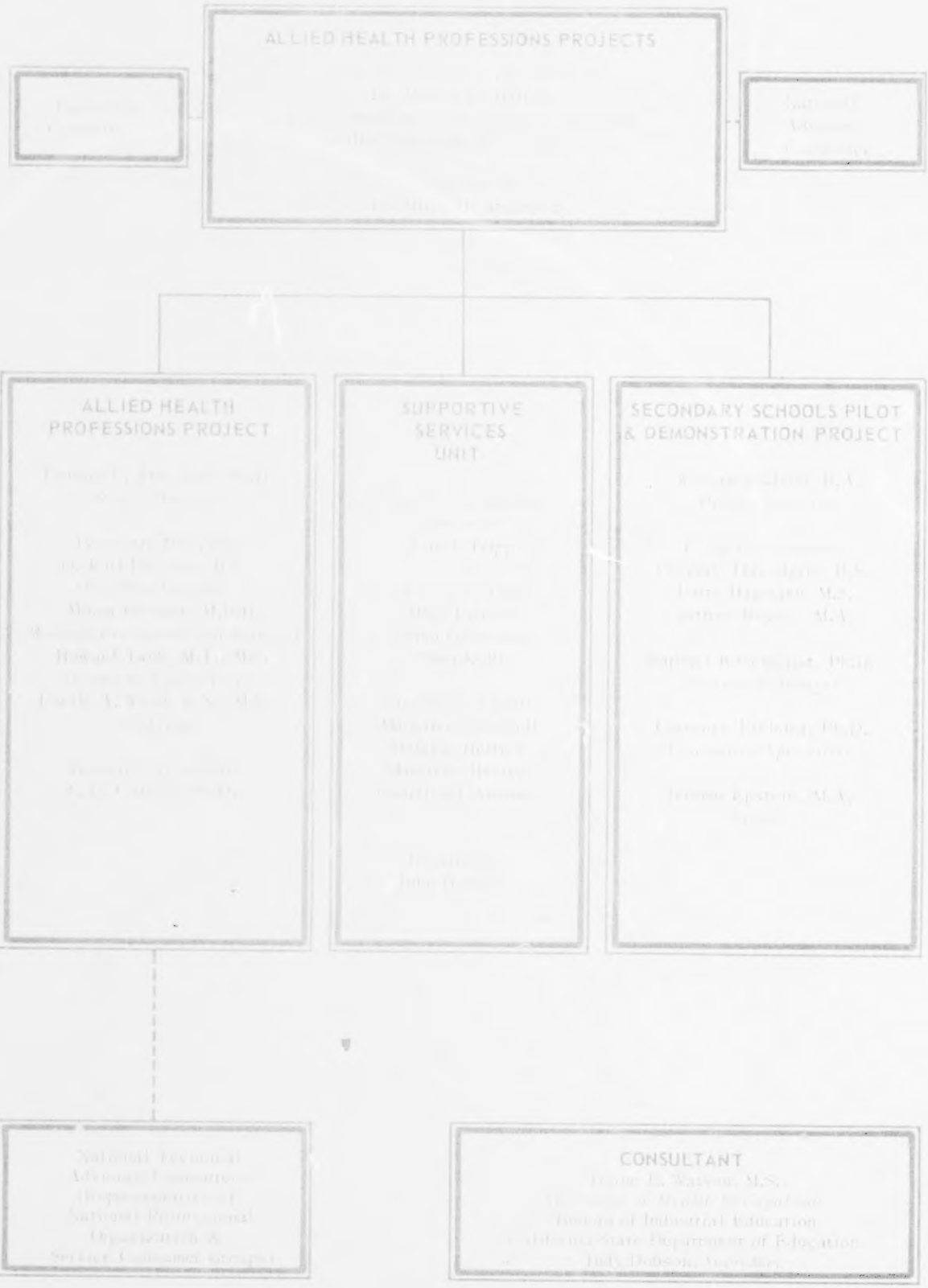
ACTION TAKEN:

SUGGESTIONS FOR REVISION:

INSTRUCTOR_____

SCHOOL_____

DATE_____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